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Three Essays Evaluating Health Impacts of the National School Lunch Program

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THREE ESSAYS EVALUATING HEALTH IMPACTS OF THE NATIONAL SCHOOL LUNCH PROGRAM

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by
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ABSTRACT

This research focuses on the health impacts of participation in the National School Lunch Program, a program providing free and reduced-cost lunches for income-eligible students and minimally subsidizing lunches for income-ineligible students. In the past decade, increasing incidence of childhood obesity, particularly among low-income individuals has drawn scrutiny over the NSLP's role in the health of student-aged children.

The first chapter introduces the reader to the NSLP, providing a history of the program since its inception at the turn of the 20^{th} century and addressing current issues in the economic literature regarding health impacts of program participation. The second chapter examines four econometric models estimating the effect of NSLP participation on obesity and finds mixed results.

Much of the previous literature assumes that all NSLP participants receive nutritionally equivalent meals, regardless of school or student characteristics. The third and fourth chapters use novel datasets to investigate the validity of this assumption. Chapter Three examines menu offerings of the NSLP across school districts, highlighting variability in menu composition across income levels. Chapter Four addresses factors affecting students' selection of the daily entrée, including race, gender, age, and income-eligibility. Key results include: 1) students attending wealthier school districts are offered more entrees, fruits and vegetable choices per week, possibly resulting in nutritionally superior meals; 2) students receiving free lunches are more likely than students purchasing paid-price lunches to choose entrees with more fat and carbohydrates and less protein.

DEDICATION

“In every walk with Nature one receives far more than he seeks.”

- John Muir

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TABLE OF CONTENTS

Table of Contents (Continued)

LIST OF TABLES

List of Tables (Continued)

Table | Page

List of Tables (Continued)

Table Page

LIST OF FIGURES

List of Figures (Continued)

CHAPTER ONE

INTRODUCTION

The National School Lunch Program (NSLP) provides free and reduced-cost lunches for eligible students, as well as minimally subsidizing paid lunches for students that are not eligible. Students with household incomes of 130 percent of the poverty line or less are eligible for the free lunch. Students with household incomes between 130 percent and 185 percent of the poverty line are eligible for the reduced-price lunch. Students with household incomes over 185 are income-ineligible but may purchase a “full-price” lunch; roughly 32 percent of all lunches served fall in this category (Food and Nutrition Service 2013a). More than eighty percent of all primary and secondary schools choose to participate in the program, serving over 5 billion lunches annually to 31 million children in pre-kindergarten through 12th grade (Currie 2003; Food and Nutrition Service 2013a).

Recently, economists and nutritionists have investigated the relationship between negative health outcomes (such as high sodium intake or large Body Mass Index (BMI)) and participation in the NSLP, citing rising obesity levels among school-age children a cause for concern. Is the positive correlation between BMI participation in the NSLP the result of high calorie, high fat school lunches? Or is the positive correlation due to selection bias into the program? While studies have concluded that NSLP participants consume more calories, fats, and sodium at lunch than non-participants (Bhattacharya, Currie, & Haider 2004; Campbell et al. 2011; Gleason & Suitor 2003; Hanson & Olson 2013), the relationship between participation and obesity remains murky. Research by

Millimet, Tchernis, and Husain (2010) and Schanzenbach (2009) suggest a positive relationship while research by Gunderson, Kreider & Pepper (2012) and Gleason and Dodd (2009) suggest a negative relationship between participation and obesity.

My dissertation is comprised of three papers. The first, “Are National School Lunch Program Participants More Likely to be Obese? Selection and Identification Issues,” provides a summary and critique of the current literature on the causal effects of participation in the NSLP on obesity. Using data from the National Health and Nutrition Examination Survey (NHANES), I estimate the treatment effect of participation in the NSLP on three measures of obesity (BMI, percent body fat, and waist to height ratio) applying four methods seen in the literature: 1) ordinary least squares regression, 2) recursive bivariate probit model, 3) non-parametric monotone instrumental variable (MIV) approach, and 4) regression discontinuity. The results are equivocal: treatment effects calculated with the first two models are positive; treatment effects with models three and four are negative. The causal relationship between participation in the NSLP and rates of childhood obesity remains unclear, partly due to concerns about the validity of each model. The simplistic OLS regression does not account for the endogeneity of participation, however the more complex bivariate probit model requires a valid instrument to correctly identify the causal effect and results may depend heavily on the strong distributional assumptions. Models three and four require the assumption of conditional mean monotonicity in order to estimate an average or local average treatment effect. This assumption is not supported by the data, thus invalidating the nonparametric MIV bounds and possibly the fuzzy regression discontinuity results.

Model validity is not the only issue in the current economic literature. A second issue not addressed is understanding *how* and *what* "participation" is measuring. For my analysis described above, I define a participant as a student that purchases school lunch five days a week.[1] However, other studies have defined a participant as loosely as a student that "usually" purchases lunch. This vagueness is due in part to a difference in survey question. The NHANES survey to parents asks if a child ever purchases a school lunch and if so, how many. The Early Childhood Longitudinal Study: Kindergarten Cohort (used in Millimet, Tchernis, & Husain 2010 and Schanzenbach 2009) asks parents if a child "usually" purchases a school lunch; participants answer in the affirmative but do not tell how often they purchase a lunch. This makes comparing results from different authors challenging.

Moreover, *what* is participation in the NSLP measuring? It is serving as a proxy for consumption of a qualifying meal. Using participation as a proxy for consumption requires the inherent assumption that all school lunches provide equivalent levels of nutrition. While there are federal guidelines mandating minimum nutrition standards, school lunches are not equal across all school districts in all states. One reason for this is the differences among cafeteria kitchens. The majority of schools are equipped with a full kitchen in which to prepare meals but some schools rely on off-site kitchens or pre-made meals (Gordon et al. 2007). School finances can contribute to the type of meal provided as well. While all schools are given the same federal reimbursements per meal, additional state and local revenue can be allocated to food services to increase the quality or

[1] The results changed little when this is reduced to include 4 or 5 days a week.

quantity of food choices. Once a menu is set, students are able to choose among different entrees, fruits, vegetables, milk, and grains offered on a given day. For example, in the 2004/05 school year, the median number of different entrees served per day was three; 18 percent of schools offered six or more entrees (Gordon et al. 2007). Thus, the nutritional value of a qualifying school lunch can vary across and within school districts. The second and third papers in my dissertation try to address this issue in two different ways.

The second paper, "What's for Lunch? Determinants of National School Lunch Program Menus," examines menu offerings of the NSLP across schools, highlighting variability in menu composition (e.g., number of fruits, vegetables, and entrees served weekly) across income levels. If low-income school districts offer recipients a less nutritious meal than their higher-income counterparts, this may exacerbate rather than alleviate the trend toward low-income childhood obesity. Furthermore, any menu variation across school demographics such as race or geographic region may muddle analysis of the NSLP based on participation rates. I create a new dataset providing menu composition along with school and community demographics from 816 elementary schools across the United States using publically available information. Schools were chosen in three stages. First, to provide a sample representing a large number of students, a school from the largest district (in terms of attendance) in each state was randomly selected. Second, to ensure income variability within the sample, the sampling frame was split into deciles based on income and 50 schools were randomly selected from each decile. Third, to ensure within-state income variability, a school from the 10^{th}, 50^{th}, and 90^{th} percentile of each state was selected. Menus from the 2012-2013 school year were compiled by accessing each school's website. Because menus are almost always created at the district level, no more than one school per district is sampled. These new data were combined with school- and district-level data from the Common Core Data (CCD), county-level income and educational attainment data from the American Community Survey (ACS), and state-level data from School Health Policies and Programs (SHPPS). While controlling for school district racial profile, urbanicity, enrollment, region, education level of adults, and relevant food policies, household income does affect the composition of a NSLP reimbursable school lunch. There is strong evidence that wealthier districts offer elementary school students more entrée and fruit choices per week. There is weaker evidence that wealthier districts offer elementary school students more vegetable choices per week. In addition, schools with a higher proportion of students eligible to receive free- or reduced-price lunches offer elementary school students fewer entrée choices and fruit choices per week.

The third and final paper, "Does Income Effect Students' Choice Of Entrée Within National School Lunch Program Menus?" addresses the possible within-district nutritional value variation. Using a unique dataset of daily food purchases provided by a suburban school district in South Carolina, I analyze factors affecting selection of the daily entrée, including race, gender, age, and income-eligibility. The school lunch menu is set as the district level; students at the district's eleven elementary schools choose between three daily entrees and a variety of fruits, vegetables, milk, and bread. In order to be considered a qualifying lunch (in which the school is reimbursed by the government), a student must select a minimum of three items, one of which must be a fruit or vegetable. Daily purchases of the NSLP lunch options are determined by the appeal of the school menu offerings as well as financial resources available to the child. If the student has the means and does not like the menu options, he or she may opt to bring a lunch from home. Nutrition information for each of the entrées served was analyzed to determine the total calories (kCal), protein (grams), fat (grams), sodium (milligrams), and carbohydrates (grams) per entrée. Results from conditional logit models conclude that while *all* students are more likely to select entrees with more fat, sodium, and protein, students purchasing free lunches are more likely than students purchasing paid-price lunches to select entrees with more fat and carbohydrates. In addition, students purchasing free lunch are less likely to select entrees with more protein than students purchasing paid-price lunches. This research contributes to a growing body of literature pertaining to economic studies examining the relationship between participation in the NSLP and childhood obesity. The remaining sections of this chapter provide a history of the NSLP and describe the current federal, state, and local reimbursements.

Program History

The practice of providing an inexpensive or free noonday meal to students attending school in the United States dates back to the mid 19th century: early education reformers understood that compulsory education would be lost on students too hungry to concentrate while in school. Observing the extent of poverty among school children in New York City at the turn of the century, *Poverty* author Robert Hunter wrote "If it is a matter of principle in democratic America that every child shall be given a certain amount of instruction, let us render it possible for them to receive it…by making full and adequate provision for the physical needs of the children who come from the homes of poverty" (Hunter 1904). Nutrition reformers were also concerned with the quality and sanitation of meals provided at home and advocated that schools provide a well-balanced meal in order to educate students in good nutrition (Levine 2008). Most early lunch programs were funded by local charities, social organizations, religious groups, and, for some major cities, the school district.

The Great Depression significantly increased the number of children needing a free meal and introduced the first federal subsidies for school lunch in an unexpected way. In an attempt to support American farmers while helping the poor, the 1935 Agricultural Adjustment Act created a program to purchase commodity surplus and redistribute it to the unemployed and needy. These commodities were distributed to schools that employed workers from the Works Progress Administration (WPA), and schools began providing inexpensive meals with regularity. By 1942, two-fifths of United States schools provided some form of school lunch (Poppendieck 2010).

In 1946, the Richard B. Russell National School Lunch Act (NSLA) institutionalized federal subsidies for school meals. The goals of the NSLA were "to safeguard the health and well-being of the Nation's children and to encourage the domestic consumption of nutritious agricultural commodities and other food, by assisting the States…in providing an adequate supply of foods and other facilities for the establishment, maintenance, operation, and expansion of nonprofit school lunch programs" (P.L. 79-396 1946). In exchange for federal cash and commodity subsidies, participating schools were required to serve a lunch providing one-third to one-half of Recommended Daily Allowances (RDA) for children 10 to 12 years of age.[2] This "Type A" lunch consisted of a minimum of 1) one-half pint whole milk, 2) two ounces of protein, 3) six ounces of vegetable or fruit, 4) one serving of bread, and 5) two teaspoons of butter or fortified margarine.[3]

The NSLA directed schools to feed children in need, but left it up to each state to define "need," providing leeway for many schools to not serve any free meals. Aid was allocated to states for the provision of non-profit school lunches based on the state's total number of school-age children and the average per capita income-level, but did not specify how the money should be dispersed among each state's schools. Additionally, each state was required to match federal funds from local sources, including student payments (Kerr 1990). In order to maintain high reimbursements per lunch served, many states chose to limit the number of schools participating in the NSLP. Contributions by state varied greatly as poorer states often depended more on student payments to match federal funds. For example, in 1967 Alabama did not use any state money to finance the NSLP; in New York, only 53 percent of matching funds came from student NSLP payments. Finally, the NSLA did not provide money to cover capital and labor expenses,

[2] The first Recommended Daily Allowances were published in 1943, creating a guideline for a "balanced meal" based on seven food groups. Home economists from the National Academy of Sciences, Institute of Medicine, and the USDA's Food and Nutrition Board established the RDAs to provide a nutrition baseline for women, men, and children in case of food shortages due to World War II. Recommendations depended upon activity level, age, and gender. For teenage boys (girls), the calorie RDA ranged from 3,400 to 3,800 (2,400 to 2,800).

[3] A "Type B" lunch needed to meet ¼ to 1/3 of RDAs and a "Type C" lunch was a pint of milk. These lunches had lower reimbursement rates and were phased out by 1980.

creating a barrier to participation for low-income schools. Because of the lax requirements governing how states allocate the NSLA subsidies and what counts as matching funds, in the first twenty years the NSLP acted more as a subsidy for middle-income students than a poverty-relief program (Michelman 1976).

Two amendments to the NSLA in 1962 expanded the program to a broader group of students. First, the formula for federal appropriations to states changed to account for the NSLP participation level, creating an incentive for states to increase total participation rates (P.L. 87-688 1962). Second, the amendment authorized additional funds allocated to schools with a high percent of low-income children.[4]

The Child Nutrition Act of 1966 (CNA) continued to expand the program, increasing total funding to the program and providing additional funds to cover capital expenses and administrative costs in low-income schools. By 1968, 73 percent of school-age students were enrolled in a participating school (Gunderson 1970). The NSLA and CNA were amended in 1970 to establish uniform eligibility guidelines for free and reduced price lunches and prohibit discrimination based on income-eligibility (Ralston, et al. 2008). Students from households with incomes less than 125 percent of the poverty line were eligible for free lunch; students from households with income between 125 and 195 percent of the poverty line were deemed eligible for reduced price lunches, not to exceed $0.20 (Zucchino & Ranney 1990). Reimbursement levels were tied to the price of the

[4] Funds to support this amendment were not appropriated until the 1966 fiscal year, when Congress increased total funding to the NSLP (Kerr 1990).

lunch served, with paid-price lunch given the smallest reimbursement and free lunch the largest. These shifts in policy greatly increased access and participation to the NSLP.

Figure 1.1 illustrates the rapid increase in lunches served in the early 1970s. In 1969, 3.4 billion NSLP lunches were served to students (including both free and paid-price lunches). By 1975, 4 billion lunches were served, or a 20 percent increase from 1969. The makeup of the participants was changing as well. In 1969, 85 percent of all lunches served were paid-price lunches; by 1974, that number declined to 65 percent (Food and Nutrition Service 2013a).[5] Throughout the 1970s, the number of total NSLP lunches served continued to increase steadily while the percent of full-price lunches served decreased 14 percent. By 1979, program costs had more than tripled to 2.8 billion dollars. The per unit federal subsidy also doubled during this time period, mainly through larger cash reimbursements due to an increasing proportion of free-lunch participants (Figure 1.2). Commodity subsidies, introduced in the original NSLA as an added market for U.S. farmers, reached a peak in 1980; the total per unit commodity subsidy has declined since then.

The Omnibus Budget Reconciliation Acts (OBRAs) of 1980 and 1981 significantly impacted both participation and costs of the NSLP. Cash reimbursements for all three price-tiers were reduced $0.025 per lunch and commodity subsidies decreased $0.0575 per lunch. To offset the decrease in federal funding, the maximum price allowed for a reduced-price meal increased from $0.20 to $0.40. Income-eligibility guidelines also

[5] 1969 is the earliest year this data is consistently available.

changed: students from households with income less than 130 percent of the poverty line were eligible for free lunch and students from households with income between 130 and 185 percent of the poverty line were eligible for reduced price lunch. In an effort to reduce fraud, income-eligibility verification procedures were instituted, increasing administrative costs incurred by the school district. The OBRAs cancelled funding for facility equipment, staff training, and nutrition education. Some school districts increased the cost of a full-price lunch to make up for the decrease in overall reimbursements, while other schools dropped out of the NSLP entirely, resulting in a 7.4 percent annual reduction in the number of full-price NSLP participants and a 14 percent drop in the number of lunches served between 1980 and 1983 (Hanson & Oliveira 2012; U.S. General Accounting Office 1984). Lastly, states were required to match 30 percent of the federal cash reimbursements, less the percent that state per capita income falls below national per capita income.[6]

In the 1990s, concern with the increasing number of overweight or obese school-age children moved public attention from the cost of subsidizing school meals to the nutritional content of each meal, particularly the high percent of fats, sodium, and cholesterol. The Dietary Guidelines for Americans set in 1990 suggested that all people over the age of two limit intake to no more than 30 percent of calories from fat and no more than 10 percent of calories from saturated fat. Nutrition science had evolved faster than the components of a "Type A" lunch, defined in a time when nutritionists believed

[6] These rates have been held at 1980/81 spending levels; in the 2010 fiscal year, state spending on food service comprised only 3 percent of current expenditures nationwide (Cornman, Young, & Herrell, 2012).

that school-age children needed diets high in fat in order to thrive (Sims 1998). In 1976, the component requiring all lunches include two teaspoons of either butter or margarine was removed and schools were allowed to offer reduced-fat and skim milk in addition to whole milk (Levine 2008). However, federal commodities distributed to schools still included large amounts of items high in fat, sodium, and cholesterol such as beef and cheese.

The 1991/92 School Nutrition Dietary Assessment (SNDA-I) conducted in part by the USDA estimated that the average school lunch had 38 percent of calories from fat and 15 percent of calories from saturated fats, both much higher than the current suggested levels (Poppendieck 2010). In response, the Healthy Meals for Healthy Americans Act was passed in 1994 requiring all reimbursable meals conform to the Dietary Guidelines for Americans by 1996. Unfortunately, results from the most recent SNDA conducted in the 2009/10 school year (SY) show that only 35 percent of schools offered NSLP lunches containing at most 30 percent of calories from fat and only 14 percent of schools offered NSLP lunches consistent with *all* dietary guidelines. Following the Healthy Meals for Healthy Americans Act, in 1995 the School Meals Initiative for Healthy Children initiated "Team Nutrition," a program requiring more nutrition education for students and training for school personnel (Sims 1998).

Continued concern over program nutrition and access enabled the Child Nutrition and WIC Reauthorization Act of 2004. The act required schools develop a wellness plan specifying nutrition and physical fitness goals and reduced the income-eligibility burden for both households and schools. Eligible households can remain authorized to receive free or reduced price lunch for one year, regardless of changes in income. Also, households already receiving benefits from another food assistance program (such as food stamps) are offered "direct certification" without filling out additional paperwork, reducing schools' administrative costs.

Most recently, the nutrition standards of reimbursable NSLP lunches have been modified to include more whole grains, fruits, and vegetables (U.S. Department of Agriculture 2012). Beginning in SY 2012/13, the federal guidelines require cafeterias serve at least one food item from each of the following food components: 1) meat or meat alternative, 2) bread or starch, 3) fruit, 4) vegetable, and 5) milk. In order to qualify as a reimbursable lunch, a student must select at least three components, one of which must be either a fruit or a vegetable. In addition, a lunch should provide between 550 and 660 calories, limit calories from saturated fat to 10 percent, and limit average sodium intake to less than 640 milligrams per meal. In an effort to include a greater variety of vegetables, schools must offer at least one serving per week of dark green, starchy, and red/orange as well as one serving per week of legumes and other vegetables. Appendix A outlines the specific requirements regarding fruits and vegetables. Schools meeting these new standards receive a "performance-based reimbursement" of $0.06 to cover the additional cost of providing a more healthful meal (P.L. 111–296 2010). The next section outlines the current system of reimbursement in more detail.

Current NSLP Reimbursements

Federal reimbursements to school districts are based on the number of lunches served at each price. To be reimbursed, each school food authority (SFA) records the number of free, reduced-price, and paid lunches served. Additional federal subsidies come in the form of entitlement and bonus commodities. SFAs are given a per meal allotment to purchase entitlement commodities at a competitive rate from USDA approved distributors. These commodities include meats, cheese, produce, and grains. Bonus commodities are donated to schools when the USDA determines foods are in surplus; these include dry beans, canned crushed pineapple, and frozen cherries (Ralston et al. 2008). In 2005, entitlement and bonus commodities made up on average 17 percent of total food budgets (Ralston et al. 2008). Federal funds are a function of both the reimbursement rates and the household income level of the SFA's student body.

Annual federal reimbursements for the i^{th} SFA can be calculated as

$$(1.1) \quad Fed_i = \phi \bar{L}_{free,i} + \rho \bar{L}_{reduced,i} + \psi \bar{L}_{paid,i} + \bar{L}_i \left[I(\nu)_i + I(\pi)_i + \kappa \right] + Bonus$$

The total number of lunches served in SFA i, $\bar{L}_i$, is the sum of $\bar{L}_{free,i}, \bar{L}_{reduced,i}, \bar{L}_{paid,i}$, the total number of free, reduced-price, and paid-price lunches served, respectively. Reimbursement rates ϕ, ρ, ψ are the base subsidy rates for free, reduced-price, and paid-price lunches, respectively. SFAs receive the largest reimbursement for free lunches and the smallest reimbursement rate for paid-price lunches, thus $\phi > \rho > \psi$. In addition to the base subsidy rates, qualifying SFAs may receive additional per meal reimbursements based on financial need and meal quality. SFAs serving more than 60 percent free or reduced-price lunches qualify for an additional subsidy, ν, for each lunch served, thus

$$I(\nu)_i = \nu \text{ if } \frac{\bar{L}_{free,i} + \bar{L}_{reduced,i}}{\bar{L}_i} > 0.60; \text{ else } 0.$$

After passing a certification process, SFAs meeting the updated nutritional guidelines also qualify to receive an additional per meal reimbursement, π.[7] This subsidy was added in the 2012/13 school year to help schools meet the new guidelines (P.L. 111–296 2010). Let $I(\pi)_i = \pi$ if the SFA is certified and $I(\pi)_i = 0$ otherwise. All SFAs are entitled to receive funds earmarked to purchase commodities. Let κ be the subsidy allotted for entitlement commodities. Entitlement subsidies must be spent on commodities selected by the USDA. Lastly, let *Bonus* be the in-kind donations received by SFAs from bonus commodities. Table 1.1 lists the subsidy rates for SY 2011/12 through 2013/14.

In order to receive federal subsidies, each state is required to contribute a minimum of 30 percent of a portion of the 1981 OBRA cash reimbursement level, less the percentage that the state's per capita income falls below the national per capita income (U.S. Department of Agriculture 2012). The OBRA levels are set at \$0.30, \$0.15, and \$0.0275 for each free, reduced-price, and paid-price lunches. Each state may elect to provide additional funds. Let $Income_{State,i}$ be the per capita income of the i^{th} SFA's state and $Income_{US}$ be the per capita income in the United States. Annual state revenue for the i^{th} SFA can be calculated as

[7] To qualify to receive this performance-based subsidy, an SFA must submit a sample weekly menu to the state, where it is examined to make sure it meets or exceeds the nutritional guidelines (See Table 1.1)

$$(1.2)\quad State_i \geq \delta\left(0.30\bar{L}_{free,i} + 0.15\bar{L}_{reduced,i} + 0.0275\bar{L}_{paid,i}\right)$$

where

$$\delta = \begin{cases} 0.30 \text{ if } Income_{State,i} \geq Income_{US} \\ \left[0.30 - \left(1 - Income_{State,i} / Income_{US}\right)\right] \text{ otherwise} \end{cases}.$$

Districts also generate local revenues through local taxes and payments from students. Together, state and local revenues make up only nine percent of total NSLP funding (Cornman, Young, & Herrell 2012). Local taxes and student lunch purchases make up the two main revenue streams. Annual local revenue for the i^{th} SFA can be calculated as

$$(1.3)\quad Local_i = \omega_i \bar{L}_{reduced,i} + \mu_i \bar{L}_{paid,i} + \tau_i T_i + Y_i \ .$$

The first two terms represent revenues from student purchases. Local revenue may also be collected by the SFA's city or town through a tax, T_i (e.g. property tax). The proportion of taxes given to the education budget and specifically to the production of school meals, τ_i, depends on local preferences and political environment. Lastly, Y_i represents the local revenue collected by local charities or social organizations (e.g. Parent Teacher Association).

Recall that each school district may set the cost to the student for reduced-price and paid-price lunches, with conditions. Let ω_i be the cost to the student of a reduced-price lunch, where $\omega_i \leq \$0.40$. Let μ_i be the cost to student of a paid-price lunch. In the 2011/12 school year, the average paid-price lunch cost \$1.78 and the base subsidy rate was \$0.26. The average SFA received at least \$2.04 per paid-price lunch and \$2.77 per free lunch, suggesting that the federal free and reduced-price reimbursements are also subsidizing the cost of paid-price lunches (Food and Nutrition Service 2013c). This may also suggest that students purchasing paid-price lunches are sensitive to price increase and SFAs trying to maintain high participation rates are reluctant to increase prices.

Federal involvement in the National School Lunch Program began as a mechanism to eliminate surplus agricultural commodities while providing for needy children. Since 1946, the program has expanded in both access and scope, serving over 5 billion lunches to 92 percent of all school-age students annually (Currie 2003). Federal funding per meal has increased overtime, partly due to the increase in the percent of free and reduced lunch participants. Public opinion is mixed on whether the meal delivers the most healthy and appealing lunch.

Table 1.1. NSLP Subsidy Rates

	Rate ($)		
	2011/12	2012/13	2013/14
Free (ϕ)	2.77	2.86	2.93
Reduced-Price (ρ)	2.37	2.46	2.53
Paid-Price (ψ)	0.26	0.27	0.28
High-need (ν)	0.02	0.02	0.02
Performance (π)	--	0.06	0.06
Entitlement (κ)	0.2225	0.2225	0.2225

Notes: School food authorities (SFA) serving more than 60 percent of free- or reduced-price lunches are eligible to receive "high-need" subsidy. Performance subsidies are given to SFAs that meet or exceed the nutritional guidelines set in January, 2012 and have been state certified for doing that. Entitlement subsidies must be spent on commodities selected by the USDA. Due to the higher cost of living, reimbursement rates are higher in Hawaii and Alaska. Source: U.S. Department of Agriculture 2012

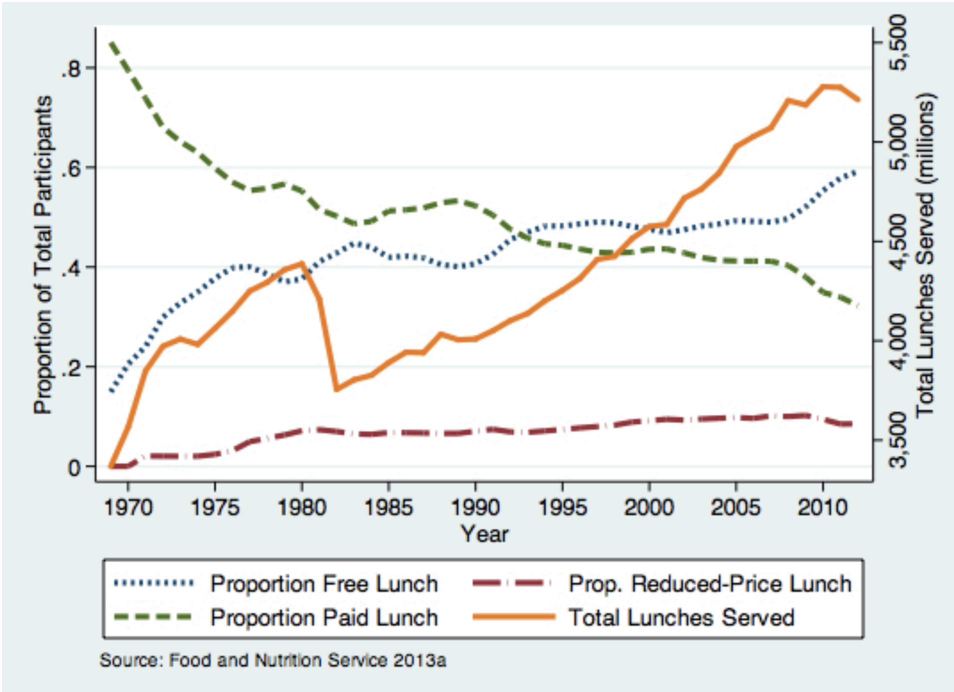

Figure 1.1. NSLP Participation, 1969 - 2012

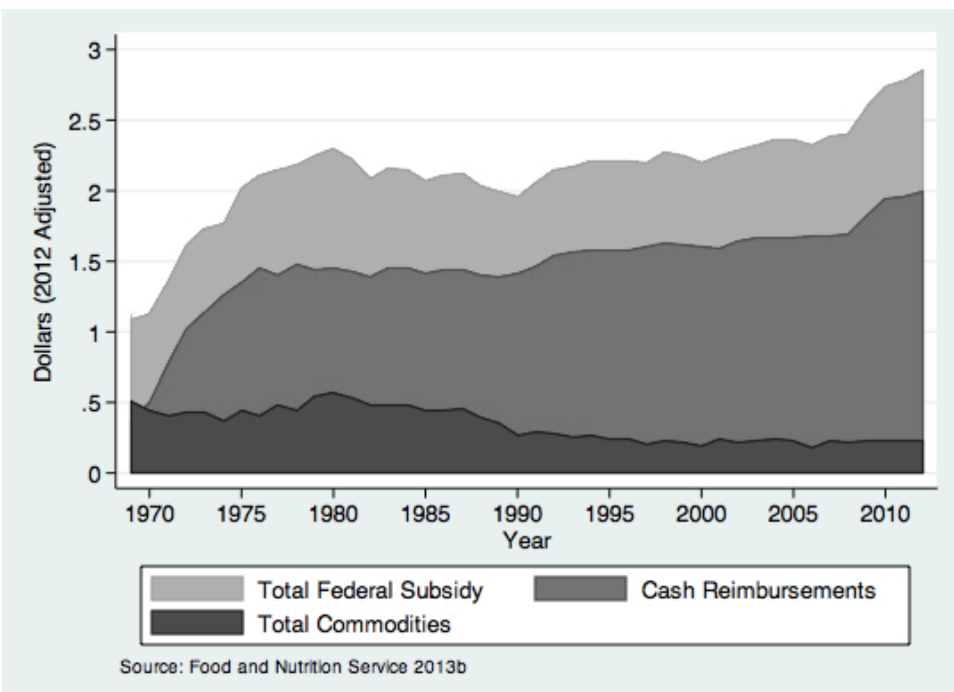

Figure 1.2. NSLP Costs Per Lunch Served, 1969 - 2012

CHAPTER TWO

ARE NATIONAL SCHOOL LUNCH PARTICIPANTS MORE LIKELY TO BE OBESE? SELECTION AND IDENTIFICATION ISSUES

Introduction

In the past decade, the nutritional content National School Lunch Program (NSLP) has become a target of consumer advocates and politicians concerned about the increasing rates of childhood obesity. Although the source of the obesity epidemic is debated in the literature with some authors pointing to a sedentary lifestyle (Blair & Brodney 1999) and genetics (Comuzzi & Allison 1998) as causes, most researchers cite increased consumption as the main culprit (Chandon & Wansink 2007a and 2007b; Hill & Peters 1998). Since the NSLP is offered at more than eighty percent of all primary and secondary schools and provides lunches to over 31 million students annually, the nutritional quality of the meals—good or bad—may have a significant impact on childhood health (Ogden & Carroll 2010; Currie 2003).

Current economic research on the relationship between participation in the NSLP and obesity is equivocal. While some studies conclude that participation contributes to obesity (Schanzenbach 2009; Millimet, Tchernis, & Husain 2010), a more recent study focusing on only low-income students suggests the opposite (Gunderson, Kreider, & Pepper 2012). This paper adds to the literature by estimating the effect of participation on obesity using approaches from three previous studies: recursive bivariate probit from Millimet, Tchernis, & Husain (2010), regression discontinuity from Schanzenbach

(2009), and nonparametric treatment effects from Gunderson Kreider and Pepper (2012). While each of these studies uses different datasets, we conduct the analysis using the same sample from the National Health and Nutrition Examination Survey (NHANES), thus allowing better comparisons across econometric models.

The majority of economic, nutrition, and medical research use body mass index (BMI) to measure whether or not an individual is obese because it is an easy to calculate and unobtrusive estimate using the ratio of weight to the square of height. However, it is known in the medical community that BMI is not always the best measure of an individual's adiposity (fat content) nor is it the best indicator of health risks associated with obesity, such as cardiovascular disease, high blood pressure, and Type-2 diabetes (Parks, Smith, Alston 2010; Prentice & Jebb 2001; Smalley et al 1990). We add to the economic literature two new measures of obesity: percent body fat and waist to height ratio.

We find estimation of the effect depends on the model: OLS regression and recursive bivariate probit model estimates find a positive effect of participation in the school lunch program on the likelihood of being obese. Contrarily, regression discontinuity design and nonparametric bounds estimation procedures identify a negative, but insignificant, effect of participation on the likelihood of being obese. The positive effect of the NSLP on obesity is removed when nonparametric estimation is used.

Literature Review

Identification issues are inherent in many economic problems, and estimating the relationship of the NSLP on childhood obesity is no exception. To begin, selection into the NSLP is not random; many of the same populations at higher risk for obesity are more likely to choose to participate in the NSLP (Currie 2003; Ogden & Carroll 2010). Furthermore, participants are not a homogenous group. Unlike most government programs providing food for low-income children, any child can participate in the NSLP regardless of income. The NSLP provides free and reduced-cost lunches for income-eligible students as well as minimally subsidizing paid lunches for students that are income-ineligible. Students with a household income of 130 percent of the poverty line or less are eligible for the free lunch. Students with household incomes between 130 percent and 185 percent of the poverty line are eligible for the reduced-price lunch. Students with household incomes over 185 percent are income-ineligible but may purchase a "full-price" lunch.[8]

While all previous studies have controlled for income when assessing the impact of participation on childhood obesity, most have not distinguished between participants receiving free or reduced price lunches (referred to as income-eligible students) and participants receiving a full price lunch (income-ineligible students). Two exceptions include Gunderson, Kreider, and Pepper (2012), who analyze the impact for income-

[8] In 2013, the poverty line for a family of four is $23,550 (U.S. Department of Health and Human Services 2013).

eligible students and Schanzenbach (2009), who analyzes the effect of participation for income-ineligible students.

There has been a significant amount of research about the NSLP within the economics literature as well as the nutrition science literature. Until recently, results have been descriptive in nature and have not considered the effects of non-random selection into the program. Current analyses of the relationship between the NSLP and nutritional outcomes (including the rate of obesity) use a variety of methods to control for selection on unobservables, including fixed effects (Gleason & Suitor 2003), two-step Heckman procedures (Long 1991), regression discontinuity (Schanzenbach 2009), and propensity score matching (Campbell et al. 2011). Instrumental variables have, for the most part, been rejected due to minimal predictive power (Bhattacharya, Currie, & Haider 2004).

Using data from (NHANES) 1999 to 2006, Campbell et al. (2011) estimate the average treatment effect of the treated (ATET) using propensity score matching. Instead of looking at the effect of participation on weight, the authors look at specific nutritional intakes such as fat, sodium, and vitamins and find that students participating in the NSLP five days a week report consuming more Vitamin A, calcium, protein, and fat at lunch than non-participants. These results support previous research by Gleason & Suitor (2003) using OLS fixed effects model. Campbell et al. (2011) also determine that these increases in nutrients come from consuming a higher-quantity diet (not a higher-quality diet) than non-participants at lunch. The differences between participants and non-participants' food consumption at breakfast and dinner are insignificant, suggesting that participation in the NSLP may increase the probability of being obese through consuming larger quantities of food at lunch.

Schanzenbach (2009) uses panel data from the Early Childhood Longitudinal Study—Kindergarten Cohort (ECLS-K) to assess the causal effect of the NSLP on obesity. The author separates individuals into risk categories depending on their weight upon entering kindergarten and observes that income-ineligible NSLP participants are 1 to 2 percentage points more likely to be obese by end of first grade. Additionally, taking advantage of the sharp income-eligibility cutoff of 185 percent, Schanzenbach uses regression-discontinuity design (RD) to observe that income-eligible students are more likely to be obese than income-ineligible students. Due to the limitations of RD, this result only holds for students with household income around 185 percent. Using the same dataset, Millimet, Tchernis, and Husain (2010) assess the impact of both the NSLP and the School Breakfast Program (SBP). They find similar results to Schanzenbach, even though their sample includes income-eligible and ineligible students. Millimet, Tchernis, and Husain then use a bivariate probit model to estimate the impact of positive selection into the SBP. When controlling for positive selection, the authors find that the school lunch program contributes to obesity rates while the breakfast program does not.

Another way to account for endogeneity in treatment not captured by covariates is by computing bounds on average treatment effect. Gunderson, Kreider, and Pepper (2012) calculate bounds on average treatment effect of the NSLP on three negative health outcomes: self-reported poor health, household food insecurity, and obesity. The data are collected from NHANES 2002 to 2004 and the sample is limited to income-eligible students. The authors use a monotone instrumental variable assumption that each outcome is non-increasing with income such that non-participants have weakly lower outcomes. Using this nonparametric method, the authors find that under weak assumptions, the NSLP reduces the rate of poor health, food insecurity, and obesity (measured by BMI). Specifically, participation in the NSLP by income-eligible students reduces the rate of obesity by 17 percent (3.2 percentage points), contradicting Schanzenbach and Millimet, Tchernis, and Husain's results.

This brief review of the previous literature illustrates the complexity in determining a causal effect of the NSLP on childhood obesity. It appears that the school lunches provide a larger lunch with more nutrients than lunches from home (Gleason & Suitor 2003; Campbell et al. 2011). For low-income students coming from households unable to provide breakfast or dinner, participating in the NSLP may reduce malnutrition and be beneficial to overall health. For other students, the NSLP may contribute to obesity but only by a small amount. The remainder of this paper is organized as follows. The next section describes the data and provides summary statistics of variables used in the analyses. We then present four approaches to estimating the effect of the NSLP on childhood obesity. Methods and results are reported for 1) ordinary least squares regression (OLS), 2) recursive bivariate probit model, 3) nonparametric bounds estimation, and 4) regression discontinuity design. The final section offers concluding remarks.

Data

Data are obtained from NHANES. NHANES includes interviews and medical examinations of a nationally representative sample of about 5,000 U.S. citizens annually; about half are children. Clusters of households within predetermined counties are selected and one or more persons from each household are chosen to participate in the survey. Sampling weights are used to find accurate estimates and standard errors. To increase the sample size and account for any unobserved changes over time, we use a pooled cross-sectional sample of children who attended elementary, middle, and high school between 2001 and 2008 and include survey year as a dummy variable.

All data used in the analysis come from the household interviews, with the exception of body measurements obtained in the medical examinations. These measurements are used to calculate three measurements of obesity used as outcomes in the analyses: body mass index (BMI), percent body fat, and waist to height ratio. The head of household, defined as a household member 18 years or older that rents or owns the residence, provides all information pertaining to the household and may assist minors in their individual interview (Centers for Disease Control and Prevention 2009). Like all self-reported data, NHANES may have reliability issues. For example, the respondent may be unfamiliar with the specific household management, such as household income. Furthermore, under-reporting of participation in government programs such as the NSLP may occur, biasing estimates (Gunderson, Kreider, & Pepper 2012).

Outcomes

We use three indicators of obesity as outcome variables: BMI, percent body fat, and waist to height ratio. First, the indicator variable BMI_i measures whether the i^{th} student is obese (BMI_i =1) or not (BMI_i =0). A child is defined as obese if his or her BMI is greater than the age and gender-specific threshold, $BMI_{i,95\%}$. This threshold is calculated by the Center for Disease Control (CDC) as greater than the 95th percentile for weight based on growth charts. Second, the indicator variable $Body\ Fat_i$ measures whether the i^{th} child has high percent body fat ($Body\ Fat_i$=1) or not ($Body\ Fat_i$=0). A child is considered to have high fat content if the total body fat is greater than 30 percent (Reilly, Wilson, & Durnin 1995). Body fat measurements require specialized equipment to measure and therefore are less often used than BMI. However, this more refined measurement does distinguish between muscle and fat. Third, the indicator variable $WtH\ Ratio_i$ measures whether child i has a waist to height ratio greater than 0.5 ($WtH\ Ratio_i$=1) or not ($WtH\ Ratio_i$=0). An individual with a waist to height ratio greater than 0.5 is considered obese (Browning, Hseih, & Ashwell 2010). This measure of central adiposity is easy to calculate and may be a more sensitive predictor of cardiovascular disease and diabetes than BMI (Gelber et al. 2008; Browning, Hseih, & Ashwell 2010).

Control Variables

A child's body composition depends on age, gender, race, calories consumed and calories burned, and genetics. For example, females are more likely to store energy as fat instead of muscle and children with obese parents may be genetically predisposed to obesity.

NHANES includes myriad health, socio-economic, and nutritional outcomes, but information on parental height, weight, or health is unfortunately not provided and thus the genetic component of body composition remains unobserved. Instead, birth weight is included to control for genetic and biological factors. An appropriate measure of calories burned (exercise) is not available across all years, so two measures of inactivity are included in the analysis: average daily hours watching television and using the computer. We expect that the more time spent at either activity, the fewer hours spent engaged in physical activity and thus the more likely a child is obese. Two-day dietary recall information is provided for only a very limited number of individuals, so a measure of calorie input is not included in the analyses.

To control for characteristics across households, education, income, and marital status of the head of household are included as covariates. Household education is measured by the education attainment of the female head of household. Female education level is used instead of male because we assume that in most households the female adult makes most decisions about food, including whether the child brings a lunch from home instead of eating a school lunch. Household income is measured as the income to poverty ratio (PIR); a PIR of 2 means a household's income is 200% of the poverty line. Measuring income relative to poverty is helpful in some of the analyses because it identifies income eligible students (PIR < 1.85). Additionally, because the poverty line changes annually, PIR does not need to be adjusted by the consumer price index (CPI). Table 2.1 provides details of all variables used in the analysis.

Summary Statistics

The sample includes 6,410 students in elementary, middle, or high school who participated in the NHANES interview and medical examination. Only students attending schools that serve school lunch are included. Descriptive statistics of key variables can be found in Table 2.2. The average age within the sample is 10.6 years old and 47 percent of the sample attends elementary school. The average PIR for all students is 252 percent of the poverty level. For a family of four in 2008, this is equivalent to approximately $53,000. 14.8 percent of all students sampled are obese, as measured by BMI, 16.8 percent have high percent body fat, and 29.2 percent of all students sampled have large waist to height ratios. This result suggests that *Body Fat* is more closely correlated with *BMI* than *WtH Ratio*; in fact, 17.2 percent of students identified as not obese have large waist to height ratio while only 7.6 percent of students classified as not obese have high body fat. Forty percent of all students participate in the school lunch program five days per week.

Similarly to previous research, we find significant differences with NSLP participants and non-participants as well as between obese and non-obese children (Dunifon and Kowaleski-Jones 2001; Ogden & Carroll 2010). Both obese students and NSLP participants are more likely to come from lower-income households: on average non-participants have a household income of 313 percent of the poverty line compared to 216 percent for NSLP participants. The difference between household income among obese and non-obese students is smaller but still significant. On average, obese students in the sample are 0.23 pounds heavier at birth than non-obese students, suggesting the possibility of an unobserved genetic component of obesity. The majority of students sampled are non-Hispanic white. Although Mexican Americans make up only 12.30 percent of the sample, 53.9 percent of all NSLP participants are Mexican American, 18.7 percent are white, and 14.9 percent are black.

The summary statistics for household education seem unusual. Twenty-three percent of the students sampled come from households where the female head of household is a college graduate. Interestingly, 25.7 percent of NSLP participants sampled come from households where the female is a college graduate while only 10.9 percent of non-participants come from households where the female is a college graduate. It may be possible that as the female's level of education increases, her time is more valuable and she chooses not to prepare a lunch for the child.

Measuring the Effect of Participation

This section presents four approaches to estimating the effect of National School Lunch Program participation on childhood obesity measured through BMI, percent body fat, and waist to height ratio. We begin with OLS regression. Second, results of the recursive bivariate probit model similar to Millimet, Tchernis, and Husain (2010) are presented. The third approach recreates the nonparametric bounds approach used by Gunderson, Kreider, and Pepper (2012) but includes two new outcomes. Lastly, the fourth approach borrows from Schanzenbach (2009) by using RD design to estimate the local average treatment effect of participation. For the sake of brevity, we focus on the interpretation of the treatment effect and do not discuss the effects of the other covariates. However, all results are presented in Tables 2.3 through 2.7.

Approach One: Ordinary Least Squares Regression

The first approach in determining the effect of participating in the NSLP on childhood obesity is the OLS regression. It is well known that a linear regression model will not provide consistent estimates when modeling binary outcomes because it ignores the discreteness of the variable; this approach serves primarily as a baseline comparison for the subsequent methods. The regression models are defined as:

$$(2.1)\quad BMI_i = \alpha_{BMI} + \mathbf{x}_i'\beta_{BMI} + \mathbf{h}_i'\delta_{BMI} + \mathbf{g}_i'\gamma_{BMI} + NSLP_i\tau_{BMI} + \varepsilon_{i,BMI}$$

$$(2.2)\quad Body\ Fat_i = \alpha_{BF} + \mathbf{x}_i'\beta_{BF} + \mathbf{h}_i'\delta_{BF} + \mathbf{g}_i'\gamma_{BF} + NSLP_i\tau_{BF} + \varepsilon_{i,BF}$$

$$(2.3)\quad WtH\ Ratio_i = \alpha_{WtH} + \mathbf{x}_i'\beta_{WtH} + \mathbf{h}_i'\delta_{WtH} + \mathbf{g}_i'\gamma_{WtH} + NSLP_i\tau_{WtH} + \varepsilon_{i,WtH}\ .$$

Let $\mathbf{x}_i'$ be a vector of individual covariates including age, gender, and race. Let $\mathbf{h}_i'$ be a vector of health indicators that contribute to increased measures of obesity (birth weight, daily television use, and daily computer use) and $\mathbf{g}_i'$ be a vector of household demographics including education, income, marital status, and survey year. The indicator variable $NSLP_i$ measures whether student *i* participates in the school lunch program ($NSLP_i$ =1) or not ($NSLP_i$ =0). Let BMI_i, $Body\ Fat_i$, and $WtH\ Ratio_i$ be the discrete obesity measurements of student *i,* as previously defined. Let ε_i be the error term.

Results of the OLS regression are similar across all three models (Table 2.3). The overall fit of the models is very low with R^2 between 3.5 percent and 6.7 percent. The estimates in Table 2.3 are not weighted to account for survey design, however we find no significant difference between weighted and non-weighted results. We find statistically insignificant and small coefficients on *NSLP* ranging from 0.008 to -0.007. This suggests that participating in the NSLP increases your probability of being obese (measured by *BMI*) by less than 1 percentage point. Contrarily, participating in the NSLP decreases your probability of having high percentage of body fat by 0.7 percentage points. These estimates are similar in magnitude to results in Schanzenbach (2009). Similar results are found when health and household characteristics are not controlled (i.e., when $\mathbf{h}_i'$ and $\mathbf{g}_i'$ are not included in equations 2.1 - 2.3).

This model assumes that participation in the NSLP is exogenous. However, it is likely that many of the observable covariates and unobservable characteristics impacting the decision to participate may also impact the probability of being obese. The next approach tries to account for potential endogeneity of *NSLP* due to nonrandom selection.

Approach Two: Recursive Bivariate Probit Model

The recursive bivariate probit model allows for the endogeneity of NSLP participation but requires strong distributional assumptions of the error term. Millimet, Tchernis, and Husain (2010) use this model “to assess the impact of positive selection” into the School Breakfast Program and note that while the model is identified without exclusion restrictions, the bivariate probit model will not provide consistent estimates without a valid instrument. We use the same outcome variables and covariates as described in the first approach:

(2.4)
$$\begin{aligned} &1)\ BMI_i{*} = \mathbf{x}_i'\beta_{BMI} + \mathbf{h}_i'\delta_{BMI} + \mathbf{g}_i'\gamma_{BMI} + \tau_{BMI} NSLP_i + \varepsilon_{i1,BMI}, \\ &\qquad BMI_i = 1 \text{ if } \mathrm{BMI}_i{*} > BMI_{i,\,95\%},\ \text{else } 0 \\ &2)\ NSLP_i{*} = \mathbf{x}_i'\lambda_{BMI} + \mathbf{g}_i'\gamma_{BMI} + \varepsilon_{i2,BMI},\ \ NSLP_i = 1 \text{ if } NSLP_i{*} > 0,\ \text{ else } 0 \end{aligned}$$

(2.5)
$$\begin{aligned} &1)\ Body\ Fat_i{*} = \mathbf{x}_i'\beta_{BF} + \mathbf{h}_i'\delta_{BF} + \mathbf{g}_i'\gamma_{BF} + \tau_{BF} NSLP_i + \varepsilon_{i1,BF}, \\ &\qquad Body\ Fat_i = 1 \text{ if } Body\ Fat_{ii}{*} > .30,\ \text{else } 0 \\ &2)\ NSLP_i{*} = \mathbf{x}_i'\lambda_{BF} + \mathbf{g}_i'\gamma_{BF} + \varepsilon_{i2,BF},\ \ NSLP_i = 1 \text{ if } NSLP_i{*} > 0,\ \text{ else } 0 \end{aligned}$$

(2.6)
$$\begin{aligned} &1)\ WtH\ Ratio_i{*} = \mathbf{x}_i'\beta_{WtH} + \mathbf{h}_i'\delta_{WtH} + \mathbf{g}_i'\gamma_{WtH} + \tau_{WtH} NSLP_i + \varepsilon_{i1,WtH}, \\ &\qquad WtH\ Ratio_i = 1 \text{ if } WtH\ Ratio_i{*} > 0.5,\ \text{else } 0 \\ &2)\ NSLP_i{*} = \mathbf{x}_i'\lambda_{WtH} + \mathbf{g}_i'\gamma_{WtH} + \varepsilon_{i2,WtH},\ \ NSLP_i = 1 \text{ if } NSLP_i{*} > 0,\ \text{ else } 0 \end{aligned}$$

In Equations 2.4 – 2.6., $NSLP_i$ is simultaneously determined because it is endogenous to the three outcomes, BMI_i, $Body\ Fat_i$, and $WtH\ Ratio_i$. The first equation in each model includes vectors of individual, health, and household explanatory variables defined in the previous section as $\mathbf{x}_i'$, $\mathbf{h}_i'$ and $\mathbf{g}_i'$, respectively. These variables are selected to control for possible household and environmental factors. The second equation in each model does not include covariates controlling for health.

To find consistent estimators of the model, the log likelihood function for each bivariate probit model is maximized:

(2.7)
$$LLF = \sum_{i=1}^{n} \ln \Phi_2\left(q_{i1}\left(\mathbf{x}_i'\beta_{Y_1} + \mathbf{h}_i'\delta_{Y_1} + \mathbf{g}_i'\gamma_{Y_1} + NSLP_i\tau_{Y_1} \right),\ q_{i2}\left(\mathbf{x}_i'\lambda_{Y_1} + \mathbf{g}_i'\gamma_{Y_1} \right),\ q_{i1}q_{i2}\rho_{Y_1} \right)$$

where

$$\Phi_2(\bullet) = Pr\left[Y_1 = y_{i1},\, NSLP = y_{i2} \middle| \mathbf{x},\mathbf{h},\mathbf{g},\, \text{NSLP}\right] = \int_{-\infty}^{\mathbf{x}_i'\lambda+\mathbf{g}_i'\gamma} \int_{-\infty}^{\mathbf{x}_i'\beta+\mathbf{h}_i'\delta+\mathbf{g}_i'\gamma+\tau NSLP} \phi_2\left(z_1,\, z_2,\, \rho_{Y_1}\right) dz_1\, dz_2$$

$$q_{ij} = \begin{cases} 1 & \text{if } y_{ij} = 1 \\ -1 & \text{if } y_{ij} = 0 \end{cases} \quad \forall\, j = 1, 2 \ .$$

The log-likelihood function, *LLF*, is the summation of the four possible combinations of Y_1 and *NSLP*. Let Y_1 be the chosen measure of obesity (either *BMI*, *Body Fat*, or *WtH Ratio*). The standard normal bivariate distribution, $\Phi_2(\bullet)$, requires both error terms ε_{1,Y_1} and ε_{2,Y_1} have a mean of zero and variance of one. The covariance (or disturbance term) between ε_{1,Y_1} and ε_{2,Y_1} is ρ_{Y_1}. If the $\rho_{Y_1} = 0$, $NSLP_i$ is exogenous to the chosen measure of obesity. If $\rho_{Y_1} \neq 0$, the error terms ε_{1,Y_1} and ε_{2,Y_1} are positively or negatively correlated, depending on the sign of ρ_{Y_1}. This may indicate selection bias on unobservables as well (Altonji, Elder, Taber 2005; Millimet, Tchernis, and Husain, 2010). It is important to note that a non-zero disturbance term may be due to true correlation between childhood obesity and NSLP participation as well as specification error within the model.

Table 2.4 provides the estimated coefficients for the recursive bivariate probit model. Again, results across the three models are similar. The coefficient τ_{Y_1} ranges from is 0.705 to 0.805 and is statistically significant in the *BMI* and *WtH Ratio* models, suggesting that participation in the school lunch program increases the likelihood of being obese when measured as an individual's BMI or waist to height ratio. Participation in the NSLP is not significant when *Body Fat* is the outcome. The disturbance term is estimated to be negative and statistically different than zero. This is a surprising and a somewhat counterintuitive result: after accounting for individual and household characteristics and the effect of NSLP participation on obesity rates, there is a significant negative correlation between unobservables in the two equations, indicating that obese students are less likely to participate in the school lunch program. Recall that this term is due to either true correlation or specification error in the model. If the model is specified appropriately, this result indicates negative selection into the school lunch program.

The marginal effects of NSLP participation on the three health outcomes are also included in Table 2.4. All three marginal effects are positive and statistically significant. The probability of being obese (Y_1=*BMI*) is 11.7 percentage points higher for students participating in the school lunch program. The probability of having a high percentage of body fat increases 9.0 percentage points for participants and the probability of having a large waist to height ratio increases 18.3 percentage points for students participating in the NSLP. This estimate is significant and supports studies finding increased fat intake of NSLP participants (e.g. Gleason & Suitor 2003; Campbell et al. 2011) and those finding positive relationships between participation and obesity (e.g. Millimet, Tchernis, and Husain 2010; Schanzenbach 2009). However, without a valid instrument, a causal effect of participation in the NSLP on childhood obesity cannot be determined with the bivariate probit model. The next approach uses nonparametric methods to partially identify the average treatment effect without restrictive parametric assumptions.

Approach Three: Nonparametric Bounds

The previous models have dealt with endogenous treatment selection by imposing strict parametric assumptions (recursive bivariate probit model) or ignoring them completely (OLS regression). In contrast, the third approach uses nonparametric bounds to partially identify the average treatment effect (ATE). We observe $\mathbf{x} = (w, z)$, a set of covariates within $\mathbf{X} = \mathbf{W} \times \mathbf{Z}$ defining each subpopulation. Let y_1 be a student's potential health outcome if participating in NSLP and let y_0 be a student's potential health outcome if not participating in NSLP. For this analysis, y_t includes *BMI*, *Body Fat*, and *WtH Ratio*. The average treatment effect is

$$(2.8) \quad ATE = E\left[y_1 | \mathbf{x}\right] - E\left[y_0 | \mathbf{x}\right]$$

where

$$E\left[y_1 | \mathbf{x}\right] = pE\left[y_1 | \mathbf{x},\ NSLP = 1\right] + (1-p)E\left[y_1 | \mathbf{x},\ NSLP = 0\right]$$
$$E\left[y_0 | \mathbf{x}\right] = pE\left[y_0 | \mathbf{x},\ NSLP = 1\right] + (1-p)E\left[y_0 | \mathbf{x},\ NSLP = 0\right]$$
$$p = \Pr\left(NSLP = 1 | \mathbf{x}\right)$$
$$E\left[y_t\right] \in [0,1]$$

For each student, we observe either y_1 or y_0, a binary outcome, but we do not observe the counterfactual where $E\left[y_t | \mathbf{x},\ NSLP \neq t\right]$. We know, however, that the expectation must lie between 0 and 1. Unless participation in the NSLP is randomly assigned, a point estimate of *ATE* will be biased due to potential selection on unobservables. Without including any further assumptions, Manski (1990) developed "worst-case" bounds by replacing the unobserved expectations with the bounded values of y_t. For each value of $\mathbf{x}$, let ATE_{WC} be defined as:

(2.9)
$$ATE_{WC} \in \Big[pE\big[y_1 | \mathbf{x}, NSLP = 1\big] - p - (1-p)E\big[y_0 | \mathbf{x}, NSLP = 0\big], \\ pE\big[y_1 | \mathbf{x}, NSLP = 1\big] + (1-p) - (1-p)E\big[y_0 | \mathbf{x}, NSLP = 0\big]\Big].$$

The worst-case bounds are not very informative. By definition, they must cover zero and have a width of one in the case of binary outcomes. The ATE_{WC} for $y_t = BMI$, $y_t = Body$ Fat, and $y_t = WtH\ Ratio$ are shown in Table 2.5. The sample is divided into 20 groups defined by the PIR and an appropriately weighted ATE_{WC} calculated for each group.[9] Covariates in $\mathbf{x}$ limit the sample to students between the age of 6 and 17 attending school that offers NSLP; unlike Gunderson, Kreider, and Pepper, we include income-eligible and ineligible students. In finite samples, bounds other than ATE_{WC} are biased. However, with more than 400 observations in each group, the bias should be negligible (Kreider et al. 2011). At worst, participation in the NSLP increases the obesity rate by 42.6 percentage points. At best, participation decreases the obesity rate by 57.4 percentage points. Similar results are found for *Body Fat* (-0.595, 0.405) and *WtH Ratio* (-0.539, 0.461).

Inclusion of additional assumptions allows these bounds to be tightened to produce a more informative result without depending on strong distributional assumptions (Manski 1990; Manski & Pepper 2000). A common assumption (and an underlying assumption for

[9] Because some $\mathbf{x}$ are empty sets, the sample must be divided into groups. Estimates are similar when using 10 groups.

valid instrumental variables) is mean-independence: the mean outcome for each treatment is equal across all subpopulations. If covariate z is an instrumental variable, then the worst-case bounds for each $\mathbf{x}$ can be tightened to:

$$(2.10)\quad \begin{aligned} ATE_{IV} \in \Big[&\sup_z \big(pE[y_1|\mathbf{x}, NSLP=1] \big) - \inf_z \big(p + (1-p)E[y_0|\mathbf{x}, NSLP=0] \big), \\ &\inf_z \big(pE[y_1|\mathbf{x}, NSLP=1] + (1-p) \big) - \sup_z \big((1-p)E[y_0|\mathbf{x}, NSLP=0] \big) \Big] \end{aligned}$$

ATE_{IV} are included in Table 2.5 using household PIR as an instrument for participation in NSLP. The ATE_{IV} on *Body Fat* states that assuming students from households with varying income have the same mean health outcome, participation in the NSLP will at worse increase the probability of having high percent body fat by 10.7 percentage points and at best decrease the probability of having high percent body fat by 31.0 percentage points.

However, it is much more likely that PIR is a monotone instrumental variable (MIV). That is, we expect that the probability of negative health outcomes (*Body Fat*, *BMI*, and *WtH Ratio*) weakly decrease with PIR, as in Gunderson, Kreider, and Pepper (2012). Formally, the negative MIV assumption states that for each treatment t, $E[y_t|w, z=z_1] \geq E[y_t|w, z=z_2]$, where z is an ordered set and. $z_1 \leq z \leq z_2$. The average treatment effect using the MIV assumption produces bounds that are smaller than worst-case bounds but larger than IV bounds. Let ATE_{MIV} be

(2.11)

$$ATE_{MIV} \in \left[\sup_{z_1 \le z}\left(pE\left[y_1 \middle| x, z = z_1, NSLP = 1 \right]\right) - \inf_{z_2 \ge z}\left(p + (1-p) E\left[y_0 \middle| x, z = z_2, NSLP = 0 \right]\right), \right.$$
$$\left. \inf_{z_2 \ge z}\left(pE\left[y_1 \middle| x, z = z_2, NSLP = 1 \right] + (1-p)\right) - \sup_{z_1 \le z}\left((1-p) E\left[y_0 \middle| x, z = z_1, NSLP = 0 \right]\right) \right].$$

ATE_{MIV} bounds are also uninformative. The ATE_{MIV} on *WtH Ratio* states that assuming students from households with lower income have weakly higher *negative* health outcomes, participation in the NSLP will at worse increase the probability of having a large waist to height ratio by 22.8 percentage points and at best decrease the probability of having a large waist to height ratio by 51.7 percentage points. While the MIV assumption may seem "innocuous" (Gunderson, Kreider, & Pepper 2012), our sample data suggest that even this assumption is incorrect. Figure 2.1 graphs each expected outcome by PIR. The relationship does not appear monotone (negative or positive) across any values of PIR. Even if analysis is restricted to income-eligible students, the expected values of *BMI*, *Body Fat*, and *WtH Ratio* appear to fluctuate between PIR values of 0 and 1.85.

A more common assumption in the literature is selection on unobservables. Models that assume exogenous selection (e.g., OLS regression) will calculate biased treatment effect estimates if positive or negative selection exists. Although the bivariate probit model estimated above found possible negative selection through the covariance term ρ, it is generally assumed that unobserved characteristics associated with obesity are positively related to participation in the NSLP (Currie 2003). We now formalize the assumption of positive selection, or monotone treatment selection (MTS) assumption (Manski & Pepper

2000) within the ATE framework. In terms of this analysis, the MTS assumption states that a student participating in the NSLP is likely to have no better *negative* health outcome on average than non-participants. Thus the bounds of the expected outcomes are now:

$$\begin{aligned} 0 \leq E\left[y_1 \middle| \mathbf{x}, NSLP=0\right] \leq E\left[y_1 \middle| \mathbf{x}, NSLP=1\right] \leq 1 \\ 1 \geq E\left[y_0 \middle| \mathbf{x}, NSLP=1\right] \geq E\left[y_0 \middle| \mathbf{x}, NSLP=0\right] \geq 0 \end{aligned}.$$

The MTS assumption does not change the lower bound of ATE_{WC} but does decrease the upper bound. This result is intuitive: if positive selection exists, we expect estimates assuming exogenous selection to be biased upward. Thus the ATE_{MTS} has the same lower bound of equation 2.9 and the bounds are now

$$\text{(2.12)} \qquad \begin{aligned} ATE_{MTS} \leq\ & pE\left[y_1 \middle| \mathbf{x}, NSLP=1\right] + (1-p)E\left[y_1 \middle| \mathbf{x}, NSLP=1\right] \\ & - pE\left[y_0 \middle| \mathbf{x}, NSLP=0\right] - (1-p)E\left[y_0 \middle| \mathbf{x}, NSLP=0\right] \end{aligned}.$$

The estimates of ATE_{MTS} for each outcome are listed in Table 2.5. Including the MTS assumption tightens the lower bounds for all outcomes and finds negative upper bounds for *Body Fat* and *WtH Ratio*. Assuming positive selection, at worst participating in the NSLP 1) increases the probability of being obese by less than 1 percentage point, 2) decreases the probability of having high percent body fat by 3.7 percentage points, and 3) decreases the probability of having a large waist to height ratio by 1.6 percentage points. Unlike the MIV assumption, the authors know of no test or figure used to evaluate the validity of the MTS assumption. However, the assumption of positive MTS seems much more likely than exogenous treatment selection or negative MTS.

Lastly, although we question the validity of the MIV assumption, we present the combined MIV and MTS assumption because it may be applicable in other research scenarios. Let $ATE_{MIV+MTS}$ be

$$(2.13)\quad ATE_{MIV+MTS} \in \left[\sup_{z_1 \le z}\left(LB_1(z_1)\right) - \inf_{z_2 \ge z}\left(UB_0(z_2)\right), \inf_{z_2 \ge z}\left(UB_1(z_2)\right) - \sup_{z_1 \le z}\left(LB_0(z_1)\right) \right]$$

where

$$\begin{aligned} LB_1(z_1) &= pE\left[y_1 | x, z = z_1, NSLP = 1\right] \\ UB_1(z_2) &= pE\left[y_1 | \mathbf{x}, NSLP = 1\right] + (1-p)E\left[y_1 | \mathbf{x}, NSLP = 1\right] \\ LB_0(z_1) &= pE\left[y_0 | \mathbf{x}, NSLP = 0\right] - (1-p)E\left[y_0 | \mathbf{x}, NSLP = 0\right] \\ UB_0(z_2) &= p + (1-p)E\left[y_0 | x, z = z_2, NSLP = 0\right] \end{aligned}.$$

Again, the positive MTS assumption only changes the upper bounds of each $ATE_{MIV+MTS}$. The lower bounds are identical to the ATE_{MIV} lower bounds. Assuming students from households with lower income have weakly higher *negative* health outcomes in addition to assuming positive selection on unobservables, at worst participating in the NSLP 1) decreases the probability of being obese by 5.4 percentage points, 2) decreases the probability of having high percent body fat by 14.7 percentage points, and 3) decreases the probability of having a large waist to height ratio by 9.8 percentage points. When including income-eligible and ineligible students, the average treatment effect for *BMI* is 2.2 percentage points higher than estimated by Gunderson, Kreider, and Pepper (2012). These estimates are not comparable: recall that the Gunderson, Kreider, and Pepper sample was limited to income-eligible students.

The nonparametric bounds approach suggests that under weak assumptions, the average treatment effect of participation in the NSLP on indicators of high percent body fat, obesity, and large waist to height ratio is at worst negative. This result contradicts the results from the first two approaches in this paper (OLS and recursive bivariate probit models) as well as results in the previous literature (including Millimet, Tchernis, and Husain (2010) and Schanzenbach (2009)). The final approach to treatment evaluation is regression discontinuity design.

Approach Four: Regression Discontinuity

Regression discontinuity takes advantage of the large disparity between the price of a school lunch for income-eligible students and income-ineligible students that increases the probability of participation for income-eligible students. By law, the reduced price lunch can cost the student no more than $0.40 while a "full price" meal on average costs $1.78[10] (Food and Nutrition Service 2013c). Because income-eligible students are not required to participate and income-ineligible students may choose to participate and pay full price, we use a fuzzy regression discontinuity design (FRD) such that

$$\lim_{PIR \downarrow PIR^0} \Pr\left(NSLP_i = 1 \middle| PIR_i = PIR^0\right) \neq \lim_{PIR \uparrow PIR^0} \Pr\left(NSLP_i = 1 \middle| PIR_i = PIR^0\right)$$

[10] The cost of a "full price" meal is set locally and thus varies from school to school. As of 2012, each "full price" lunch served is federally subsidized $0.26, much lower rate than the subsidy rate for free and reduced price lunches. State and local governments can choose to subsidize full price meals even more. For example, "full price" meals in New York City are currently set at $1.50.

where PIR^0=1.85 is the threshold. In our sample, the probability of participating in NSLP decreases from 59 percent to 73.3 percent around the threshold, PIR^0. Let the relationship between the three outcomes and participation in the NSLP be

$$(2.14)\quad BMI_i = \alpha_{BMI} + \lambda_{BMI} NSLP_i + f\left(PIR_i\right) + \upsilon_{i,BMI}$$

$$(2.15)\quad Body\ Fat_i = \alpha_{BF} + \lambda_{BF} NSLP_i + f\left(PIR_i\right) + \upsilon_{i,BF}$$

$$(2.16)\quad WtH\ Ratio_i = \alpha_{WtH} + \lambda_{WtH} NSLP_i + f\left(PIR_i\right) + \upsilon_{i,WtH}$$

where $NSLP_i$ and PIR_i are defined as before, λ_{y_i} is the local average causal effect (LATE) of participation, and υ_{i,y_i} is a vector of covariates influencing the outcome variable (age, gender, race, and birth weight). The estimand of λ_{y_i} is the ratio of the magnitude of the discontinuity in the probability of each outcome to the magnitude of the discontinuity in the probability of participating in the school lunch program[11] (Imbens & Lemieux 2007):

$$(2.17)\qquad \lambda_{y_i} = \frac{\lim_{PIR\downarrow PIR^0} E\left[y_i \middle| PIR_i = PIR^0\right] - \lim_{PIR\uparrow PIR^0} E\left[y_i \middle| PIR_i = PIR^0\right]}{\lim_{PIR\downarrow PIR^0} E\left[NSLP_i \middle| PIR_i = PIR^0\right] - \lim_{PIR\uparrow PIR^0} E\left[NSLP_i \middle| PIR_i = PIR^0\right]}$$

where y_i is student i's obesity outcome (*BMI*, *Body Fat*, or *WtH Ratio*). The LATE estimand λ is determined by using local linear regressions to estimate the outcome variable on either side of the threshold PIR=1.85 (the numerator of λ_{y_i}) and then using local linear regression again to estimate the treatment effect on either side of the threshold (the denominator of λ_{y_i}).

[11] The sharp regression discontinuity design is a special case of FRD where the discontinuity in regression of the treatment indicator is 1.

Results are presented in Table 2.6 and Figures 2.2 through 2.4. Optimal bandwidth is defined by the IK bandwidth (Imbens & Kalyanaraman 2009). Standard errors are estimated using the delta method. Figure 2.2 graphs the smoothed probability of being obese over all values of PIR. The vertical line represents the threshold value of PIR=1.85, with income-eligible students to the left of the cutoff and income-ineligible students to the right of the cutoff. A discontinuity is present at the cutoff, but it appears small. The results are not consistent with Schanzenbach's results using ECLS-K data. We find that students just above the threshold are more likely to be obese: participation in the school lunch program decreases the probability of being obese by 78 percentage points.

Although the result is statistically insignificant and the magnitude highly improbable, the negative sign is congruent with the nonparametric ATE bounds estimated above. Figures 2.3 and 2.4 show similar results for indicators of high body fat and large waist to height ratio. Participation in the NSLP reduces the probability of high percent body fat by 132 percentage points and reduces the probability of large waist to height ratio by 198 percentage points. Again, these estimates seem very unrealistic and are not significantly different than zero.

The authors calculate standard robustness checks on the validity of the FRD design. To make sure the discontinuity is not present at other thresholds, τ_{y_i} is estimated at PIR^0=2 (included in Table 2.6), PIR^0=2.5, and PIR^0=1. The coefficients at each false threshold are not significant. Another specification test is calculated by running regressions on baseline covariates *Birth Weight* and *Black, non-Hispanic* that should not affect participation in the NSLP and thus we expect continuity in each of these covariates at the threshold. As expected, neither of these coefficients is significant. The coefficient estimates do not depend on bandwidth: decreasing the bandwidth to half the size of the IK optimal bandwidth and increasing it to twice as large produces similar results. Lastly, local linear regressions estimated with and without covariates also produce similar results. If the inclusion of covariates changes the significance or sign of the estimated LATE, this may indicate misspecification of the FRD or a potential discontinuity in one or more covariates. While our specification tests indicate valid FRD design, the estimated treatment effects for *BMI*, *Body Fat*, and *WtH Ratio* are all insignificant.

Summary and Conclusions

The National School Lunch Program is one of the largest food-assistance programs in the United States, providing lunch for over 31 million students (U.S. Department of Agriculture 2012). Recent research suggests that the NSLP may not provide nutritious meals and at least one-third of schools do not meet compliance set by the *Dietary Guidelines of America* (Gleason & Suitor 2003; Campbell et al. 2011; Crepinsek et al. 2009). With childhood obesity close to 17 percent for two- to nineteen-year olds, it is imperative to understand how participation in the NSLP may be impacting childhood obesity.

Previous studies have shown that participation in the NSLP contributes to childhood obesity, most likely through the high fat and calorie content of the school lunch as well as due to selection on unobservables. However, when the sample is limited to low-income participants, participation in the NSLP reduces the occurrence of obesity. This paper adds to the economics literature in two ways. First, we estimate an individual's obesity using BMI, percent body fat and waist to height ratio because BMI may not always be the best measure of body composition. Second, we use the same sample across four different econometric approaches, allowing for a better comparison of results. Results are mixed. Using OLS regression, the estimated effect of participation on obesity (measured by *BMI*, *Body Fat*, and *WtH Ratio*) is less than 1 percentage point; using a recursive bivariate probit model, participation in the NSLP increases the probability of being obese by between 9 and 18 percentage points. When strong normality distributions are removed, these estimates reverse sign: under MIV and MTS assumptions, participation in the NSLP at worst decreases the probability of being obese 5 percentage points; estimation of a local average treatment effect around the income-eligibility threshold of 185 percent of the poverty line indicates that participation in the NSLP decreases the probability of being obese by a statistically insignificant 78 percentage points.

The causal relationship between participation in the NSLP and rates of childhood obesity is still unclear, partly due to concerns about the validity of each model. The simplistic OLS regression does not account for the endogeneity of participation, however the more complex bivariate probit model requires a valid instrument to correctly identify the causal effect and results may depend heavily on the strong distributional assumptions. Unfortunately, even the most "innocuous" assumption of conditional mean monotonicity is not supported by the data, thus potentially invalidating the nonparametric MIV bounds. The fuzzy regression discontinuity model results are only valid around the "full-price" lunch income cutoff of 185 percent of the poverty line and thus are not comparable to the other three models. These conclusions underscore the complexity in determining a causal effect of the NSLP on childhood obesity. Future research may focus on determining the precise mechanism through which the school lunch program has an effect on obesity.

Table 2.1. Variables

Variable	
Measures of Obesity	
BMI	Individual Body Mass Index (BMI) is greater than age/gender specific cutoff for obese (Yes or No)
Body Fat	Individual percent body fat is greater than 30% for obese (Yes or No)
WtH Ratio	Individual waist to height ratio is greater than .50 for obese (Yes or No)
Individual Characteristics	
NSLP	Individual participates in National School Lunch Program (NSLP) five days per week (Yes or No)
Age	Individual's age (years)
Gender	Individual's gender (Male or Female)
Race	Individual's race (Non-Hispanic White, Non-Hispanic Black, Mexican American, and Other)
Health Indicators	
Birth Weight	Individual's weight at birth (lbs)
Daily Television Use	Average hours per day individual spends watching TV (Less than 1, 1, 2, 3, 4, 5, 5+ hours)
Daily Computer use	Average hours per day individual spends using the computer (Less than 1, 1, 2, 3, 4, 5, 5+ hours)
Household Demographics	
Education	Education level of female household reference (Less than high school, high school diploma or GED, some college, college graduate or above)
Income/Poverty	Ratio of household income to federal poverty line (e.g. 1 = household income is at poverty line)
Marital Status	Marital status of household reference (Married, divorced or separated, other)
Survey Year	Year of questionnaire and medical examination (2001-2002, 2003-2004, 2005-2006, 2007-2008)

Table 2.2. Descriptive Statistics

Variable	All Students	NSLP Participants		NSLP Non-Participants	Obese Students		Non-Obese Students
NSLP Participant	40.30%	100.00%		0.00%	65.00%	***	58.80%
	(0.016)	-		-	(0.024)		(0.016)
NSLP Non-Participant	59.70%	0.00%		100.00%	35.00%	***	41.20%
	(0.016)	-		-	(0.024)		(0.016)
Obese	14.80%	16.10%	***	12.90%	100.00%	***	0.00%
	(0.006)	(0.007)		(0.008)	-		-
High Percent Body Fat	16.80%	16.40%	***	17.30%	69.40%	***	7.60%
	(0.007)	(0.008)		(0.011)	(0.023)		(0.007)
Large Waist to Height Ratio	29.20%	29.90%	***	28.20%	97.80%	***	17.20%
	(0.009)	(0.010)		(0.014)	(0.005)		(0.010)
Age	10.577	10.425	***	10.831	10.689	***	10.551
	(0.050)	(0.056)		(0.090)	(0.082)		(0.059)
Birth Weight	7.325	7.29	***	7.384	7.514	***	7.283
	(0.025)	(0.034)		(0.035)	(0.049)		(0.026)
Household Income/Poverty	2.52	2.156	***	3.131	2.19	***	2.593
	(0.053)	(0.054)		(0.060)	(0.065)		(0.053)
Race							
White, non-Hispanic	60.70%	18.70%	***	9.20%	16.80%	*	14.50%
	(0.029)	(0.023)		(0.013)	(0.022)		(0.018)
Black, non Hispanic	14.80%	14.90%	***	8.40%	15.10%	***	11.80%
	(0.018)	(0.022)		(0.014)	(0.024)		(0.018)
Mexican American	12.30%	53.90%	***	70.80%	56.60%	***	61.40%
	(0.018)	(0.033)		(0.026)	(0.036)		(0.029)
Other	12.20%	12.50%		11.70%	11.50%		12.30%
	(0.011)	(0.013)		(0.013)	(0.014)		(0.012)
Household Education							
Less than HS	19.70%	24.90%	**	22.40%	30.90%	***	22.70%
	(0.016)	(0.012)		(0.016)	(0.021)		(0.011)
HS Diploma/GED	23.90%	31.90%	***	35.90%	30.60%	**	34.00%
	(0.011)	(0.016)		(0.016)	(0.023)		(0.015)
Some College	33.50%	17.50%	***	30.80%	15.60%	***	24.10%
	(0.013)	(0.014)		(0.019)	(0.018)		(0.014)

continued…

Table 2.2 (continued). Descriptive Statistics

Variable	All Students	NSLP Participants		NSLP Non-Participants	Obese Students		Non-Obese Students
Household Education (continued)							
College Graduate	22.90%	25.70%	***	10.90%	22.90%	**	19.20%
	(0.013)	(0.019)		(0.014)	(0.021)		(0.016)
Number of Observations	6,410	4,208		2,202	1,039		5,371

Notes: Estimates are weighted appropriately for survey design and standard errors are shown in parentheses. Asterisk (*), double asterisk (**), and triple asterisk (***) indicate mean is significantly different than non-obese or non-participant population at α = 10%, 5% and 1%, respectively.

Table 2.3. OLS Regression Results

Explanatory Variable (Omitted Level)	Measure of Obesity		
	BMI	Body Fat	WtH Ratio
NSLP Participant	0.008	-0.007	0.003
	(0.012)	(0.012)	(0.014)
Individual Characteristics			
Age	0.005**	0.024***	0.012***
	(0.002)	(0.002)	(0.002)
Gender (Omitted: Female)			
Male	-0.002	-0.101***	-0.063***
	(0.011)	(0.010)	(0.012)
Race (Omitted: White, non-Hispanic)			
Black, non-Hispanic	0.021	-0.014	-0.088***
	(0.016)	(0.015)	(0.018)
Mexican American	0.017	0.004	0.043*
	(0.015)	(0.015)	(0.018)
Other	0.023	0.004	0.003
	(0.020)	(0.019)	(0.024)
Health Indicators			
Birth Weight	0.033***	0.020***	0.035***
	(0.004)	(0.004)	(0.005)
Daily TV Use (Omitted: Less than 1)			
1 Hour	-0.051	-0.075	-0.004
	(0.057)	(0.061)	(0.067)
2 Hours	-0.026	-0.091	0.021
	(0.056)	(0.060)	(0.065)
3 Hours	0.006	-0.047	0.056
	(0.056)	(0.060)	(0.065)
4 Hours	0.029	-0.038	0.074
	(0.057)	(0.060)	(0.066)
5 Hours	0.049	-0.013	0.107
	(0.058)	(0.062)	(0.067)
5 + Hours	0.08	0.007	0.141*
	(0.058)	(0.062)	(0.067)

continued…

Table 2.3 (continued). OLS Regression Results

Explanatory Variable (Omitted Level)	Measure of Obesity		
	BMI	Body Fat	WtH Ratio
Daily Computer use (Omitted: Less than 1)			
1 Hour	-0.011	-0.004	-0.02
	(0.016)	(0.015)	(0.018)
2 Hours	-0.029	0.008	-0.034
	(0.017)	(0.016)	(0.019)
3 Hours	-0.015	-0.012	-0.025
	(0.020)	(0.019)	(0.023)
4 Hours	-0.029	0.004	-0.049
	(0.028)	(0.028)	(0.032)
5 Hours	-0.03	-0.049	-0.071
	(0.040)	(0.036)	(0.044)
5 + Hours	-0.029	0.035	-0.02
	(0.039)	(0.039)	(0.045)
Household Demographics			
Poverty/Income Ratio	-0.003	-0.007	-0.014**
	(0.005)	(0.004)	(0.005)
Education (Omitted: Less than High School)			
HS Diploma/GED	-0.001	-0.002	-0.007
	(0.016)	(0.015)	(0.018)
Some College	-0.051***	-0.024	-0.044*
	(0.015)	(0.015)	(0.018)
College Graduate	-0.082***	-0.044*	-0.101***
	(0.020)	(0.019)	(0.023)
Marital Status (Omitted: Married)			
Divorced or Separated	0.047**	0.039*	0.03
	(0.016)	(0.016)	(0.018)
Other	-0.002	-0.001	-0.018
	(0.017)	(0.016)	(0.019)
Survey Year (Omitted: 2001- 2002)			
2003-2004	0.005	0.009	0.025
	(0.014)	(0.014)	(0.016)
2005-2006	0.033*	0.009	0.035*
	(0.014)	(0.014)	(0.016)

continued…

Table 2.3 (continued). OLS Regression Results

	Measure of Obesity		
Explanatory Variable (Omitted Level)	BMI	Body Fat	WtH Ratio
Survey Year (continued; Omitted: 2001- 2002)			
2007-2008	0.034	0.007	0.047*
	(0.018)	(0.016)	(0.021)
Constant	-0.091	-0.102	-0.014
	(0.069)	(0.071)	(0.079)
Number of Observations	5,546	5,203	5,493
R Squared	0.035	0.067	0.055

Notes: Asterisk (*), double asterisk (**), and triple asterisk (***) denote 10, 5, and 1 percent significance levels, respectively. Estimates shown are not weighted; there was no significant difference between weighted and non-weighted results. Similar results are found when controlling for only individual characteristics. Robust standard errors are shown in parentheses.

Table 2.4. Recursive Bivariate Probit Model Results

	Measure of Obesity					
	BMI		Body Fat		WtH Ratio	
Explanatory Variable	BMI	NSLP	Body Fat	NSLP	WtH Ratio	NSLP
NSLP Participant	0.705*		0.775		0.805***	
	(0.306)		(0.569)		(0.244)	
Individual Characteristics						
Age	0.032***	-0.058***	0.112***	-0.058***	0.050***	-0.060***
	(0.009)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Male	-0.045	0.188***	-0.438***	0.167***	-0.222***	0.191***
	(0.043)	(0.037)	(0.043)	(0.038)	(0.036)	(0.037)
Race						
Black, non-Hispanic	-0.004	0.343***	-0.153	0.352***	-0.348***	0.343***
	(0.071)	(0.050)	(0.094)	(0.052)	(0.055)	(0.051)
Mexican American	0.037	0.076	-0.012	0.073	0.073	0.085
	(0.058)	(0.051)	(0.064)	(0.055)	(0.052)	(0.052)
Other	0.049	0.097	-0.008	0.065	-0.026	0.099
	(0.075)	(0.068)	(0.081)	(0.071)	(0.067)	(0.068)
Health Indicators						
Birth Weight	0.114***		0.081***		0.093***	
	(0.016)		(0.018)		(0.014)	
Daily TV Use						
1 Hour	-0.203		-0.257		-0.015	
	(0.207)		(0.200)		(0.189)	
2 Hours	-0.081		-0.322		0.065	
	(0.200)		(0.196)		(0.184)	
3 Hours	0.037		-0.13		0.161	
	(0.198)		(0.192)		(0.183)	
4 Hours	0.114		-0.097		0.21	
	(0.200)		(0.194)		(0.185)	
5 Hours	0.18		-0.009		0.297	
	(0.204)		(0.198)		(0.188)	
5 + Hours	0.272		0.057		0.386*	
	(0.203)		(0.197)		(0.187)	
Daily Computer Use						
1 Hour	-0.042		-0.018		-0.056	
	(0.053)		(0.057)		(0.048)	
2 Hours	-0.105		0.03		-0.094	
	(0.056)		(0.060)		(0.051)	
3 Hours	-0.054		-0.051		-0.067	
	(0.068)		(0.074)		(0.062)	

continued…

Table 2.4 (continued). Recursive Bivariate Probit Model Results

	Measure of Obesity					
	BMI		Body Fat		WtH Ratio	
Explanatory Variable	BMI	NSLP	Body Fat	NSLP	WtH Ratio	NSLP
Daily Computer Use						
4 Hours	-0.104		0.015		-0.138	
	(0.098)		(0.103)		(0.088)	
5 Hours	-0.1		-0.178		-0.195	
	(0.135)		(0.155)		(0.127)	
5 + Hours	-0.101		0.128		-0.048	
	(0.127)		(0.131)		(0.119)	
Household Demographics						
Poverty/Income Ratio	0.037	-0.205***	0.033	-0.211***	0.02	-0.206***
	(0.030)	(0.015)	(0.056)	(0.015)	(0.026)	(0.015)
Education						
HS Diploma/GED	0.045	-0.213***	0.071	-0.232***	0.037	-0.218***
	(0.057)	(0.054)	(0.073)	(0.056)	(0.052)	(0.054)
Some College	-0.103	-0.301***	-0.001	-0.302***	-0.036	-0.294***
	(0.069)	(0.053)	(0.093)	(0.055)	(0.058)	(0.053)
College Graduate	-0.221*	-0.353***	-0.087	-0.339***	-0.189*	-0.342***
	(0.094)	(0.068)	(0.123)	(0.071)	(0.081)	(0.068)
Marital Status						
Divorced or Separated	0.180**	-0.106*	0.156**	-0.082	0.110*	-0.102
	(0.055)	(0.053)	(0.059)	(0.056)	(0.051)	(0.054)
Other	0	0.002	0.001	0.003	-0.042	0.018
	(0.058)	(0.058)	(0.063)	(0.060)	(0.054)	(0.059)
Constant	-2.551***	1.508***	-2.939***	1.519***	-2.177***	1.511***
	(0.329)	(0.102)	(0.434)	(0.105)	(0.292)	(0.103)
Rho	-0.412		-0.481		-0.484**	
	(0.189)		(0.356)		(0.151)	
NSLP Marginal Effect	0.117***		0.090***		0.183***	
	(0.081)		(0.073)		(0.116)	
Number of Observations	5,546		5,203		5,493	
Log-Likelihood	-5,796.35		-5,136.62		-6,391.58	
Chi-Square	996.2		1,137.15		1,123.80	
	(<0.0001)		(<0.0001)		(<0.0001)	

Notes: Asterisk (*), double asterisk (**), and triple asterisk (***) denote 10, 5, and 1 percent significance levels, respectively. Estimates shown are not weighted; there was no significant difference between weighted and non-weighted results. Robust standard errors are shown in parentheses. Survey year is included in the model but not reported. The following categorical variable levels are omitted to prevent multicollinearity: Gender (Female), Race (White, non-Hispanic), Daily Television or Computer Use (Less than 1 Hour), Female Education (Less than HS), Marital Status (Married).

Table 2.5. Nonparametric Bounds

Assumption	BMI	Body Fat	WtH Ratio
Worst Case	[-0.574, 0.426]	[-0.595, 0.405]	[-0.539, 0.461]
IV	[-0.268, 0.236]	[-0.310, 0.107]	[-0.195, 0.205]
MIV	[-0.548, 0.243]	[-0.572, 0.137]	[-0.517, 0.228]
MTS	[-0.574, 0.006]	[-0.595,-0.037]	[-0.539,-0.016]
MIV + MTS	[-0.548,-0.054]	[-0.572,-0.147]	[-0.517,-0.098]

Notes: Bounds found with appropriately weighted estimates. Income/Poverty Ratio is used as IV and MIV. To insure non-empty sets, the sample was divided into 20 groups. Similar results occur when the sample is only divided into 10 groups. Standard errors were not calculated.

Table 2.6. Regression Discontinuity Results

Measure of Obesity	λ (NSLP Coefficient)	Falsification: Threshold = 200% Income/Poverty	Bandwidth
Obese	-0.781	1.364	1.245
	(1.196)	(3.523)	
Body Fat	-1.321	-1.820	1.158
	(1.694)	(4.062)	
WtH Ratio	-1.980	0.241	1.229
	(2.419)	(2.365)	
Baseline Covariates			
Black, non-Hispanic	0.971	-1.439	1.171
	(1.467)	(9.776)	
Birth Weight	-3.189	-2.657	0.922
	(4.595)	(4.384)	

Notes: Each row represents a separate regression. Number of observations in each regression is 5,907. No covariates are included, although results are similar when covariates for age, race, and gender are included. Bandwidth estimated with Imbens-Kalyanaram optimal bandwidth.

Figure 2.1. Validity of Using Income as Monotone Instrumental Variable

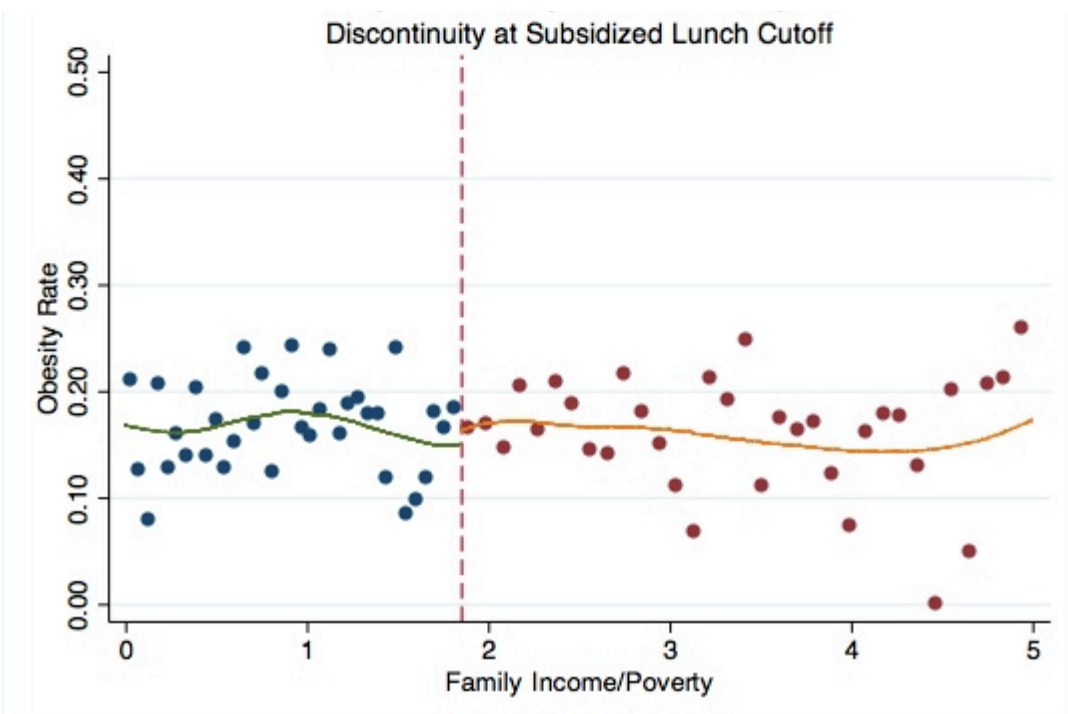

Figure 2.2. Obesity Indicator by Income/Poverty Ratio

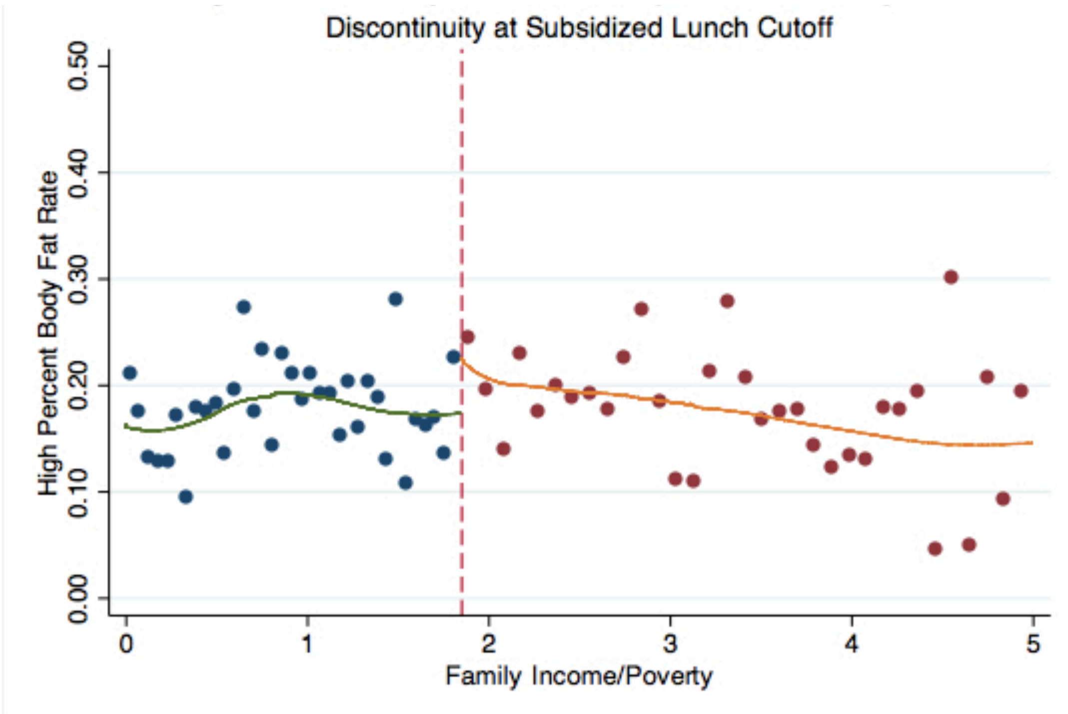

Figure 2.3. High Percent Body Fat Indicator by Income/Poverty Ratio

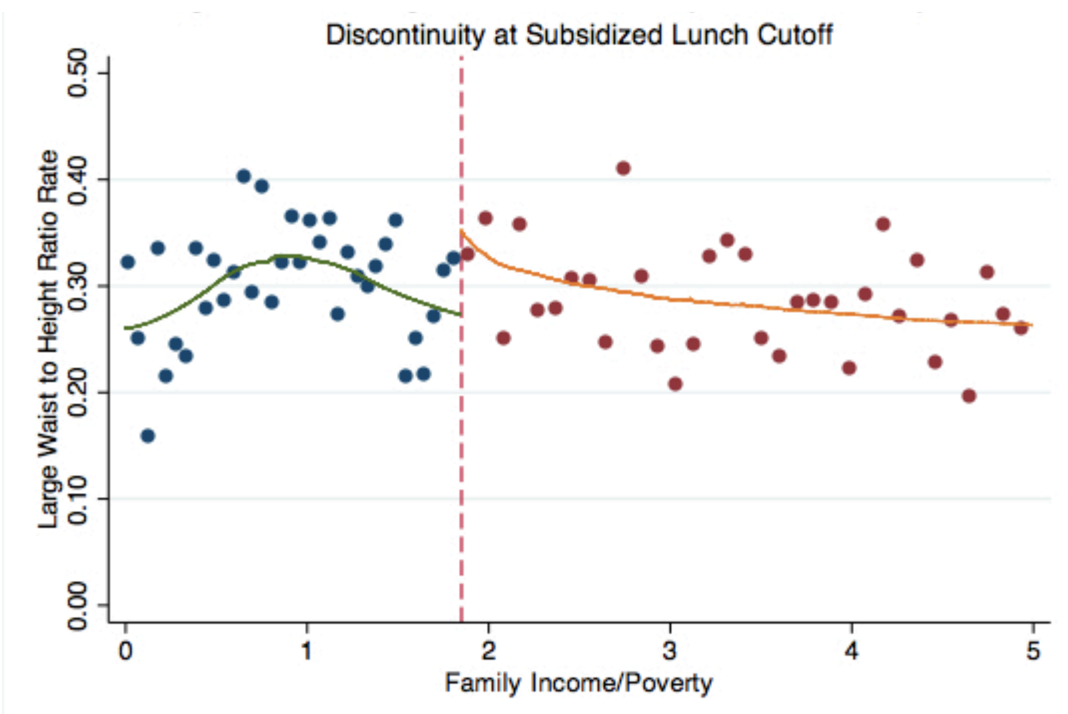

Figure 2.4. Large Waist to Height Ratio Indicator by Income/Poverty Ratio

CHAPTER THREE

WHAT'S FOR LUNCH? DETERMINANTS OF THE NATIONAL SCHOOL LUNCH PROGRAM MENU

I. Introduction

The last decade has brought increased scrutiny by nutrition advocates, policy makers, and school lunch personnel over the role of the National School Lunch Program (NSLP) on the rising rates of childhood overweight and obesity. Advocates of the NSLP say that the program provides equal or better nutrition than what would be provided otherwise. However, research on the nutritional quality of the NSLP is equivocal. It appears that school lunches provide a larger lunch in terms of grams of food, but also provide more essential vitamins and minerals than lunches from home (Gleason & Suitor 2003; Gordon et al. 2007b; Campbell et al. 2011). For low-income students coming from households unable to provide breakfast or dinner, participating in the NSLP may reduce malnutrition and be beneficial to overall health. For other students, the NSLP may contribute to obesity but only by a small amount. Gunderson, Kreider and Pepper (2012) found that for participants with a household income no greater than 130% of the poverty line, the NSLP reduced rates of food insecurity, poor health, and obesity.

Opponents of the NSLP say that the program is not in line with the Dietary Guidelines for Americans. The Healthy Meals for Healthy Americas Act required all school lunches "conform to Dietary Guidelines for Americans" (P.L. 103-448 1994) by 1996, but as late as 2005, only one-third of schools met the guidelines (Gordon et al. 2007a). Two analyses using longitudinal data suggest that fifth grade students participating in the NSLP are more likely to be obese than non-participants, controlling for weight in kindergarten (Schanzenbach 2009; Millimet, Tchernis, & Husain 2010). However, analyzing the long-term effects of participation in the NSLP, Hinrichs (2010) observes no significant effects on health after ten years.

Little research has examined the differences in what is served as a NSLP lunch among school districts, although differences are well documented (Gordon et al. 2007a; Levine 2008; Poppendieck 2010). School districts must comply with federal guidelines defining a qualifying school lunch, but decisions on the quality and quantity of food choices is left to the district and is determined in part by food availability, budgetary restrictions, and student preference. This paper focuses on the relationship between school district income and the variety of entrees, fruit, and vegetables available to NSLP participants.

I construct a unique dataset of 816 current school lunch menus collected from publically available school websites. To analyze what types of schools may be more likely to serve more healthful foods as part of a school lunch, these data are combined with school- and district-level data from the Common Core Data (CCD), county-level income and educational attainment data from the American Community Survey (ACS), and state-level data from School Health Policies and Programs (SHPPS). An increase in household income at the county level increases the number of entrees offered per week. This income effect is greatest in the wealthiest school districts. Additionally, there is weak evidence of positive income effects on the number of fruits and vegetables served as well. The paper proceeds as follows. Section II provides a review of the relevant literature. Section III develops a theoretical model suggesting possible avenues through which income may affect district menu composition. Section IV discusses in depth the new dataset used to generate the estimates. Section V presents model specifications, Section VI provides results, and Section VII concludes.

II. Literature Review

Amendments to the National School Lunch Act and Child Nutrition Act in the 1960s and '70s ensured that federal subsidies were allocated equally across states and that states provided free and reduced price lunches for those in need, regardless of race or gender. More recent policy changes have focused on mandating minimum nutrition standards. Even with these amendments, differences in state and local spending practices create inequalities in school lunch menus across schools. For instance, kitchen facilities differ across schools. In the 2004/05 school year, the School Nutrition Dietary Assessment Study III (SNDA-III) conducted by the Food and Nutrition Service estimates that 70 percent of schools prepare meals on-site, while 19 percent of schools receive "fully or partially prepared meals from a base or central kitchen" (Gordon et al. 2007a). The remaining 11 percent of schools prepare meals for students at that school as well as other schools.

School food authorities (SFA) work within school districts to provide non-profit food services, including the NSLP, while meeting food, labor, and indirect costs. For example, an SFA may administer food service for a school district with five elementary schools, two middle schools and a high school. The SFA is responsible for determining the total number of free-, reduced-, and paid-priced lunches, collecting federal, state, and local reimbursements, and creating menus that meet or exceed federal guidelines. SFAs usually create one menu for each school-level, e.g. one menu for all five elementary schools.

Food costs account for 46 percent of reported costs, labor accounts for 45 percent, and indirect costs account for the remainder (Bartlett, Glantz, & Logan 2008). When the full cost of a lunch exceeds the sum of the paid price and subsidy, school districts must pay the balance. A study on the cost of school meals in 2004 estimates that school districts cover 19 percent of the total cost of food service (Bartlett, Glantz, & Logan 2008).[12] For cash-strapped school districts, this may make it difficult to provide a nutritious lunch. Like providing any service, school districts with more funding may be able to provide more nutritious lunches with a larger variety of fruits, vegetables, and entrees.

A mix of federal, state, and local revenues fund public schools. Local revenues comprise about 45 percent of total revenue per school district (Cornman, Young, & Herrell 2012). In 2007, property taxes administered at the school district level accounted for 34 percent of public school funding, leading to large variations in expenditures per student across states and school districts (Chetty & Friedman 2010). For instance, 2010 current expenditures per student averaged $10,652 but ranged from $6,452 in Utah to $20,910 in Washington, DC (Cornman, Young, & Herrell 2012). Allocation of these expenditures

[12] In this study, food service includes all school nutrition programs, including the School Breakfast Program and the National School Lunch Program.

are determined by the school district and thus indirectly by the voting public who either elect officials or vote directly on public spending legislation.

Federal guidelines require cafeterias to offer at least one fruit, vegetable, grain/bread, meat/meat alternative, and milk daily. In order to qualify as a reimbursable lunch, a student must select at least three components, one of which must be either a fruit or a vegetable. The concept of offering more food components than students are obligated to select is called "offer versus serve" (OVS). Introduced as an option at high schools and middle schools in 1977, OVS was a way to cut down on food costs and food waste, as students were less likely to select items they did not intend to eat. OVS was phased into elementary schools in 1981 (Poppendieck 2010).

Although offering one meat/meat alternative is sufficient for reimbursement, most schools offer two or more per day (Gordon et al 2007b). Offering multiple entrees can increase participation by appealing to a larger range of students.[13] This is also true of vegetables and fruits. Behavioral economics research has shown that offering a choice of fruits increased the amount of fruits purchased (Just & Wansink 2009). Additional research on plate waste (the quantity of edible food not eaten at lunch) suggests that choosing from a selection of fruits and vegetables reduces plate waste by allowing students to select what they prefer (Buzby & Guthrie 2002).

[13] The meat/meat alternative food component must be offered as an entrée (e.g. Chicken nuggets or yogurt and cheese stick.) Entrées can also provide the bread or starch component of the meal (e.g. Hamburger with Bun or Pepperoni Pizza)

Opponents of the new NSLP nutrition guidelines worry that requiring schools to offer more types of vegetables will increase costs of the meal without increasing the healthfulness of what is actually consumed. These concerns may be unfounded: using menu and dietary intake data available for 397 elementary and secondary schools in the SNDA-III study, Newman (2012) evaluates the effect on consumption of offering healthy foods. The author uses tobit regressions to estimate whether students attending schools offering more whole grains, vegetables and fruits actually consume more of these items while controlling for student, family, and school characteristics such as age, BMI, household income, and school enrollment. She finds that offering more whole grains, dark green vegetables, and red-orange vegetables leads to increased consumption of these items. However, these results did not hold for schools offering more fruits.

Offering more vegetable, fruit, and entrée options may increase participation, providing greater revenues. It can also reduce plate waste and increase the healthfulness of food choices. The options offered ultimately are determined by the demand for school lunch and the school district's and SFA's ability to provide a healthy lunch on a given budget. A theoretical model is presented in the next section.

III. Theory

While the large majority of each SFA's food service revenue comes from federal reimbursements, individual states and districts may choose to provide additional revenue towards food service. For example, the SFA's city or town through a tax, e.g. property tax, may collect local revenue. The proportion of taxes given to the education budget and specifically to the production of school meals depends on local preferences and political environment. If the opportunity costs of collecting additional local revenues are too great, an SFA will choose to rely solely on federal and state funds.

Allow the SFA to act in the best interest of the students, aiming to provide a nutritious meal while following the federal guidelines for a reimbursable meal. Let x_i be a food component of a NSLP lunch, where i = 1 for fruit, = 2 for vegetable, = 3 for grain/bread, = 4 for meat/meat alternative, or = 5 for milk. The SFA gains utility from offering these components daily: $U(x_1,...,x_5)$. The SFA raises additional revenue through local chartable donations and tax revenues. The political cost associated with raising revenue is *C(R, Y),* a function of revenue, *R*, and local income, *Y*. This cost increases as more revenues are raised, such that $\partial C/\partial R > 0$. In addition, raising local raising revenue becomes less difficult in wealthier areas: $\partial C/\partial Y < 0$.

The SFA maximizes utility less political costs, subject to budget constraints and federal nutrition guidelines:

(3.1) $$\max_{\{x_1,...,x_5\}} \mathrm{U}(x_1,...,x_5) - C(R,Y)$$

s.t.

$$R = \sum_{i=1}^{5} p_i x_i$$
$$x_i \geq 1 \ \ \forall \ i$$

Revenue is the sum of the product of all food components, x_i, and their respective prices, p_i. For simplicity I assume that each component i can be priced individually; however, NSLP meals are not actually bought a la carte. Consider $\sum_{i=1}^{5} p_i$ the total price of a school meal, including both the federal reimbursement (for all meals) and the student contribution (for reduced- and paid-price lunches). In order to receive reimbursement, the SFA must provide at least one of each component daily, thus the five inequality constraints.

The Lagrangian function and first order conditions are presented below.

(3.2) $$L\left(x_i,\lambda,\mu_i\right)=U\left(x_i\right)-C\left(R,Y\right)+\lambda\left(R-\sum_{i=1}^{5}p_i x_i\right)+\sum_{i=1}^{5}\mu_i x_i$$

(3.3) $$\frac{\partial L}{\partial x_i}=\frac{\partial U}{\partial x_i}-\frac{\partial C}{\partial R}\frac{\partial R}{\partial x_i}-\lambda p_i \le 0 \ \left(=0 \text{ if } x_i>1\right) \ \forall \ i$$

(3.4) $$\frac{\partial L}{\partial \lambda}=R-\sum_{i=1}^{5}p_i x_i=0$$

(3.5) $$\frac{\partial L}{\partial \mu_i}=x_i \ \forall \ i$$

Equation 3.3 illustrates that the marginal utility gained from providing x_i, for example fruits (i=1), is less than or equal to the price of p_1 plus the marginal political cost of providing fruits as part of a reimbursable meal. Each SFA will choose the optimal number of fruits, x_1^*, on the budget line. If the cost of providing an additional fruit outweighs the marginal benefit, the SFA will only offer one fruit daily. Consider two SFAs choosing the optimal number of fruits. They both face the same prices, but one district is wealthier than the other. Given that $\partial C/\partial Y<0$, the poorer SFA may only be able to offer one fruit per day while the wealthier SFA offers two.

The National School Lunch Program is a federally funded program providing equal subsidy rates nationwide. The theoretical model presented above shows how local funding sources such as taxes and bake sales allow wealthier school districts to offer a greater number of fruits, vegetables, entrees, etc. than their low-income counterparts through reducing the marginal political cost of providing an additional food component. The next section describes the unique dataset I collected to tests this empirically.

IV. Data

Data are collected from four sources: current district and school websites, Common Core Data, the School Health Policies and Programs Study, and the American Community Survey. Table 3.1 provides descriptions of each variable and its source. The study use menu data from elementary schools only because they offer fewer a la carte options (food choices that are available for purchase outside of a qualifying NSLP lunch) than middle or high schools and a larger percent of K-5 students typically participate in the NSLP than middle or high school students (Gordon et al. 2007a; Fox & Condon 2012). Schools were chosen in three stages. First, to provide a sample representing a large number of students, a school from the largest district (in terms of enrollment) in each state was randomly selected. Second, to ensure income variability within the sample, the sampling frame was split into deciles based on county-level income and 61 schools were randomly selected from each decile. Third, to ensure within-state income variability, a school from the 10^{th}, 50^{th}, and 90^{th} percentile of each state was selected. Because menus are almost always created at the district level, no more than one school per district is sampled.

School district data are collected from the Common Core Data (CCD). The Department of Education collects data on all public elementary and secondary schools in the country, thus providing the initial sampling frame for menu collection as well as providing information about the chosen school districts and schools. The most recent district-level data available are from the CCD District Survey 2010/11 school year. Variables include the proportion of white, non-Hispanic enrolled students (*White)*, proportion of black, non-Hispanic enrolled students (*Black*), proportion of Hispanic enrolled students (*Hispanic*), proportion of other enrolled students (*Other*)[14], and whether the district is located in a predominately urban, suburban/town, or rural area (*Urban, Suburban,* and *Rural,* respectively). Total enrollment (*Enrollment*) measures the total number of students in each district. Household income (*Eligible*) is measured at the district-level by the proportion of enrolled students eligible for a free or reduced-price lunch (i.e. the proportion of students from households that fall below 185 percent of the poverty line).

Menus from the 2012/13 school year were compiled by accessing each school's website. Websites are a cost-effective way to disseminate information to parents. Most school districts include a current cafeteria menu to promote the NSLP and encourage participation. Schools and/or school districts post monthly menus either in addition to or as a substitute for sending paper lunch menus home with each student (see Appendix F for an example). Often, menus are removed from the website at the end of the month so that only the current month is available. I collected menus at three different times: August/September 2012, October/November 2012, and April/May 2013. I selected the

[14] *Other* includes Asian, Pacific Islander, American Indian, Samoan, and mixed-race students.

first five-day week of the current month and recorded the complete menu, including vegetarian options and salad bars if available. Foods were then categorized by type and the total number of entrées (*Total Entrée*), fruits (*Total Fruit*), and vegetables (*Total Vegetable*) served each week was calculated. When possible, *Total Vegetable* was further categorized into mutually exclusive subgroups, *Green Vegetable, Red/Orange Vegetable*, *Legume*, *Starchy Vegetable*, and *Other Vegetable*. These categories coincide with the USDA's current lunch guidelines and will be used as outcome variables in the regressions presented below.[15] On average, 67 percent of each district's vegetables can be categorized within the vegetable subgroups. Some menus do not list the specific type of vegetable served; i.e., a menu listing "Vegetable" would be counted as one vegetable in *Total Vegetable*, but would not be included in the vegetable subgroup analysis. Combination vegetables such as "Peas and Carrots" are counted as one vegetable in *Total Vegetable* but, to maintain mutual exclusivity, are not included in the vegetable subgroups.

In addition, the month each menu was sampled is included to capture potential timing differences due to food seasonality or lags in implementing the new NSLP guidelines. Let *Month1*=1 if the menu is from August/September 2012 and 0 otherwise. *Month2* and *Month3* are defined similarly for October/November 2012 and April/May 2013, respectively.

[15] See Appendix A for detailed vegetable classifications.

District-level variables are matched to county-level variables from the American Community Survey 5-year estimates to find median household income and adult education attainment (*Attained BA*) of the school's county. Let *Income* be the median household income of the school district county divided by 10,000. School district boundaries do not necessarily coincide with county boundaries: while only one school is sampled from each district, there are sometimes multiple districts per county.[16] For example, Cook County, Illinois is home to 9 school districts, including City of Chicago Public Schools. The median household income for Cook County is $51,457. However, *Eligible* ranges from 0.08 in the suburban Arlington Heights School District to 0.84 in the suburban Cicero School District. The City of Chicago School District has the largest enrollment in Cook County and *Eligible* is 0.76. Thus, *Income* may not always provide an accurate estimate of the household income of each district's enrolled students. For this reason, both *Income* and *Eligible* are used as measures of school district wealth. Based on the theoretical model, I expect a positive relationship between each dependent variable and *Income* and a negative relationship between each dependent variable and *Eligible*.

The average median county income in the sample is $50,664 and the average proportion of students with household income below 185 percent of the poverty line is 0.46. On average, 26 percent of adults in the district hold a bachelor's degree or higher. The sample includes wide range of school districts in terms of student enrollment: the smallest district has 69 enrolled students and the largest district has 667,273 enrolled students. On average, 62 percent of the students are considered white, 13 percent

[16] The most extreme example of this is Los Angeles County with 17 sampled districts.

considered black, 17 percent considered Hispanic, and 8 percent considered other races. Almost half of the districts sampled are identified as suburban, 27 percent are rural districts, and 25 percent are identified as urban.

Menus from some randomly selected schools were not available for one of four reasons (Fig. 3.1). First, some school districts choose not to post menus. This issue was more prevalent at lower income schools, but occurred at all income decile. Second, the school menu was posted but was out of date (not in the 2012/13 school year). This occurred most frequently at the poorest school districts. Third, no school or school district website could be found. Possible reasons may be out of date information on school closings. Lastly, an abundance of school holidays, half-days, and teacher workdays may mean that a posted menu does not include at least one 5-day week and therefore cannot be used. These school districts were removed from the random sample and others were selected in their place.

State-level policies may affect district and school level management decisions regarding menu choices. The School Health Policies and Programs (SHPPS) database provides information regarding nutritional policies in schools. The CDC collects these data every five to six years; the most recent SHPPS data are from 2006. Relevant to this analysis are three state policies requiring or recommending that schools offer students a choice between two or more different lunch entrées, fruits, or vegetables daily (*Entrée Policy*, *Fruit Policy*, and *Vegetable Policy*). Additionally, some states require each district provide a coordinator to oversee all food service (*Coordinator*) and some states require schools to prohibit access to vending machines for at least part of the day (*Vending*).[17] Lastly, each state was assigned to one of four geographic regions (*North*, *Midwest*, *South*, or *West*). Thirty-two percent of sampled districts are located in the south, 27 percent in the Midwest, 22 percent in the western United States, and 19 percent in the north.

V. Methods

The theoretical model outlined in Section III suggests that the income level of a SFA in part determines an individual district's demand for menu components such as entrees, fruits, and vegetables. I use multiple income specifications to test income effects on the total number of entrées, fruits, and vegetables served per week. As a sensitivity analysis for the effect of income on the number of vegetables served weekly, I use vegetable subgroups defined in the previous section. Five models using various income specifications are evaluated for each dependent variable: 1) *Income* cubed, 2) natural log of *Income*, 3) *Income* dummy variables, 4) *Eligible*, and 5) *Eligible* dummy variables. The sixth and seventh models use median regression to evaluate the effect of *Income* and *Eligible* on *Total Entrée*, *Total Fruit*, *and Total Vegetable*.

Covariates are added to all models to control for education-level of the adults in each district, district-level race, urbanicity and size, geographic region, the month of sampling, and district food policies. This section describes the models used for all eight dependent

[17] A complete list of policies by state and is provided in Appendix B.

variables. Additional income specifications can be found in Appendix D. Descriptive statistics and results follow in Section VII.

Ordinary least squares regression is used on the eight menu components collected from the school menu data. Let x_i be the total number of entrées, fruits, vegetables, dark green vegetables, red/orange vegetables, legumes, starchy vegetables, or other vegetables served in district *i*. *Income* is the median household income in district *i*, divided by 10,000. Let $\boldsymbol{S}_i$ be a vector of characteristics for the i^{th} school district: parental education ($Attained\ BA_i$), race ($Black_i$, $Hispanic_i$, $Other_i$; $White_i$ omitted), urbanicity ($Suburban_i$, $Rural_i$; $Urban_i$ omitted), region ($Midwest_i$, $South_i$, $West_i$; $North_i$ omitted), and the natural log of *Enrollment*. The natural log of enrollment is used because adding one additional student may have a greater impact on x_i in smaller school districts due to economies of scale. All variables are described fully in Section IV and in Table 3.1. Let $\mathbf{D}_i$ be a vector of three state-level nutrition policies: $Coordinator_i$, $Vending_i$, and $Policy_i$. The variable $Policy_i$ is *Entrée Policy* when x_i=*Total Entree, Fruit Policy* when x_i=*Total Fruit*, and *Vegetable Policy* for all other equations. Vector $\mathbf{M}_i$ contains variables indicating which month the menu was sampled ($Month2_i$, $Month3_i$; $Month1_i$ omitted). Models 1, 2, and 3 are defined by equation 3.6:

$$(3.6) \quad E\left(x_i \middle| Income_i, \mathbf{S}_i, \mathbf{D}_i, \mathbf{M}_i\right) = \alpha + f\left(Income_i\right) + \delta'\mathbf{S}_i + \gamma'\mathbf{D}_i + \lambda'\mathbf{M}_i \ .$$

A perfectly linear relationship between income and entrée choices is unlikely, so Model 1 defines $f\left(Income_i\right) = \beta_1 Income_i + \beta_2 Income_i^2 + \beta_3 Income_i^3$. Results using *Income* to the second and fourth power are similar and are included in Appendix D. As is typical of U.S. income estimates, the distribution of *Income* is right-skewed (Fig. 3.2). Taking the natural log corrects this skew and a few high-income outliers. Thus Model 2 defines $f\left(Income_i\right) = \beta_1 LnIncome_i$, where *LnIncome* is the natural log of the median household income in district *i*'s county. Note that in this case, household income is not divided by 10,000.[18] Model 3 provides another flexible form for *Income*: let $f\left(Income_i\right) = \beta\mathbf{Income}_i'$ where $\mathbf{Income}_i'$ is a vector of dummy variables such that

$$\begin{aligned}
Income_{1,i} &= 1 \text{ if } Income \le 3.5; \text{ else } 0 \\
Income_{2,i} &= 1 \text{ if } Income > 3.5; \text{ else } 0 \\
Income_{3,i} &= 1 \text{ if } Income > 4.5; \text{ else } 0 \\
Income_{4,i} &= 1 \text{ if } Income > 5.5; \text{ else } 0 \\
Income_{5,i} &= 1 \text{ if } Income > 6.5; \text{ else } 0
\end{aligned}$$

The base level, $Income_{1,i}$ is excluded from the model so that the coefficient on $Income_{2,i}$, β_2, measures the effect of district *i* moving from a median household income of less than \$35,000 to a median household income between \$35,000 and \$45,000. Note that the remaining dummy variables are not bounded from above; the variables overlap to measure the pseudo-marginal effect of an increase in income. For example, when *Total Entrée* is the dependent variable x_i, a positive coefficient β_3 implies moving from a median household income between \$35,000 and \$45,000 to an income between \$45,000 and \$55,000 increases the number of entrees offered weekly.

[18] Results using $LnIncome^2$ are provided in Appendix D.

Models 4 and 5 use *Eligible* to measure the income of school district i instead of the median household income; $f\left(Eligible_i\right)$ replaces $f\left(Income_i\right)$ in the regression equation:

$$(3.7) \qquad E\left(x_i \middle| Eligible_i, \mathbf{S}_i, \mathbf{D}_i, \mathbf{M}_i\right) = \alpha + f\left(Eligible_i\right) + \delta'\mathbf{S}_i + \gamma'\mathbf{D}_i + \lambda'\mathbf{M}_i \ .$$

Recall that *Eligible* is the proportion of students in school district i with household income less than 185 percent of the poverty line. The federal poverty line is determined annually and increases with family size. In 2013, 185 percent of the poverty line for a family of four was \$43,567.50. In Model 4, I define $f\left(Eligible_i\right) = \beta_1 Eligible_i$. Model 5 uses dummy variables similar to Model 3: let $f\left(Eligible_i\right) = \beta \mathbf{Eligible}_i$ where $\mathbf{Eligible}'_\mathbf{i}$ is a vector of dummy variables such that

$$\begin{aligned}
&Eligible_{1,i} = 1 \ \text{ if } Eligible \ \leq 0.20; \ \text{ else } 0 \\
&Eligible_{2,i} = 1 \ \text{ if } Eligible \ > 0.20; \ \text{ else } 0 \\
&Eligible_{3,i} = 1 \ \text{ if } Eligible \ > 0.40; \ \text{ else } 0 \\
&Eligible_{4,i} = 1 \ \text{ if } Eligible \ > 0.60; \ \text{ else } 0 \\
&Eligible_{5,i} = 1 \ \text{ if } Eligible \ > 0.80; \ \text{ else } 0
\end{aligned}$$

As in Model 3, these dummy variables are not mutually exclusive. Again the base level, $Eligible_{1,i}$ is excluded from the model and the coefficients are considered pseudo-marginal effects of moving from just below the cut-off to just above.

The final models move away from standard OLS regression techniques to quantile regression. Median-quantile regression can be helpful to use in cases when the distribution of the outcome variable is highly skewed and the median is more informative than the mean. Instead of finding a conditional-mean function using least squares estimation, quantile regression finds a conditional-median function using least absolute distance estimation (Koenker 2005). Models 6 and 7 are only used to evaluate *Total Entrée*, *Total Fruit*, and *Total Vegetable* due to the limited observations in each vegetable subgroup.

Let the median-quantile function of x_i be $Q(x_i)$. Models 6 and 7 are conditioned on vectors $\mathbf{S}_i$, $\mathbf{D}_i$, and $\mathbf{M}_i$. Model 6 also includes the vector of dummy variables $\mathbf{Income}_i$ and Model 7 includes the vector of dummy variables $\mathbf{Eligible}_i$.

$$(3.8)\qquad Q\left(x_i \middle| Income_i, \mathbf{S}_i, \mathbf{D}_i, \mathbf{M}_i\right) = \alpha + \beta'\mathbf{Income}_i + \delta'\mathbf{S}_i + \gamma'\mathbf{D}_i + \lambda'\mathbf{M}_i + F_{u_i}^{-1}(q)$$

and

$$(3.9)\qquad Q\left(x_i \middle| Eligible_i, \mathbf{S}_i, \mathbf{D}_i, \mathbf{M}_i\right) = \alpha + \beta'\mathbf{Eligible}_i + \delta'\mathbf{S}_i + \gamma'\mathbf{D}_i + \lambda'\mathbf{M}_i + F_{u_i}^{-1}(q)$$

The distribution of the error term on the median is $F_{u_i}^{-1}(0.50)$. If the error term is not identically distributed, (e.g. due to heteroskedasticity), $Q(\bullet)$ will vary in slope and intercept across quantiles. Complete regression results are provided for the median quantile and compared to results in Models 3 and 5 to see if OLS results are biased.

VI. Results

Descriptive Statistics

The average number of entrées offered during the sampled week is 12, or more than two per day. While all elementary school menus included at least one entrée per day, some districts offered as many as eight entrees per day (Fig. 3.3). Vegetables and fruits are offered less often: in an average week, 10 vegetable sides and 7 fruit sides are offered. Six school menus did not include any vegetables sides and 23 did not include any fruits sides. Either these schools are not following the weekly meal patterns required of a reimbursable meal or the school district does not publish daily vegetable and fruit choices. Without any further information, I assume that the published menu is correct.

On average, elementary school districts offer one green vegetable, one legume, 1.6 red/orange vegetables, 1.3 other vegetables, and almost 2 starchy vegetables each week. The range of all five vegetable subgroups is large (Fig. 3.4). For example, while most menus included one legume each week (60 percent), 179 districts (22 percent) offered no legumes and one district offered 20 legumes per week.[19] Due to the limited information provided on some menus, only 67 percent of all vegetables can be categorized into subgroups. The other 33 percent are either unclassified (e.g. "Salad") or combination vegetables ("Peas and Carrots"). Until a larger sample is collected, or more detailed menu information becomes available, regression results with vegetable subgroups should be considered preliminary and are available in Appendix C. However, this dataset can provide insight into how SFAs are adjusting to the new weekly meal pattern introduced in the 2012/13 school year requiring minimum servings of specific types of vegetables. This benefits NSLP participants nutritionally by providing vegetables with different vitamin and mineral compositions. It also is intended to introduce students to a variety of

[19] Anecdotally, the school districts offering the most number of vegetables provided a salad bar or a vegetable station where students could choose among a large selection of daily vegetables.

vegetables. Most of the menus (70 percent) were collected in April or May 2013, eight or nine months after the new requirements took effect.

While SFAs are providing vegetables within each subgroup, the within group variety is lacking. Of the vegetables offered and clearly identified, starchy vegetables are the most commonly offered (Table 3.4). Twelve percent of all vegetables offered are potatoes (including potato products such as French fries) and 5.6 percent is corn. Other starchy vegetables, such as green peas and lima beans make up another 2.6 percent of all vegetables. Almost seven percent of all vegetables offered are French fries.

Red/orange vegetables make up 15.4 percent of all vegetables offered. Carrots are by far the most popular variety: 63 percent of red/orange vegetables are carrots, either cooked or raw. Other vegetables, such as green beans, comprise close to 12 percent of all vegetables, while dark green vegetables and legumes comprise 10.1 percent each. Sixty-two percent of dark green offered are broccoli (cooked or raw).

Total Entrees

Model 1 estimates the effect of income on the number of total entrees served using a third-order income specification. Using OLS regression with robust standard errors and controlling for education-level of the adults in district *i*, students' race, urbanicity, district size, region, the month district *i*'s menu was sampled and district food policies, an increase in household income of $10,000 will increase the total number of entrees served weekly between 0.53 and 8.03 (Table 3.5). Figure 3.5 displays the marginal effect of income graphically. The blue line traces the marginal effect household income on the total number of entrees served per week across all income levels within the sample. The shaded area represents the pointwise 95 percent confidence band. There is a positive and statistically significant income effect at all income levels. In the poorest districts, a \$10,000 increase in household income would increase the number of entrees offered weekly by 2.54 per week. In the richest districts, a \$10,000 increase in income increases the number of entrees by 8.03. School districts in counties with a median household income of \$55,948 experience the smallest marginal effect: if income increases \$10,000, the number of entrees offered weekly increases by less than 1.

Model 2 estimates the effect of income on the total number of entrees served using the natural log of income. The income effect is positive and statistically significant (Table 3.6). A ten percent increase in household income would increase the number of entrees offered weekly by 0.48. For wealthier school districts, this income effect is smaller than estimated in Model 1. Model 3 estimates income effects using income dummy variables. All coefficients are positive but not statistically significant (Table 3.7). A joint F-test concludes that *Income* contributes to the number of entrees served weekly (Appendix E). Model 6 evaluates the same functional form for *Income* ($f\left(Income_i\right) = \beta'\mathbf{Income}_i$) using conditional-median instead of conditional-mean regression. As discussed in the previous section, the median provides a better measure of central tendency than the mean for highly skewed outcome variables. All but one *Income* coefficient in Model 6 is positive. School districts with household income greater than \$65,000 offer 0.12 fewer entrees per week than districts with income between \$55,000 and \$65,000, suggesting decreasing returns on income (Table 3.10). These results contradict those in Model 1 but they are also not statistically significant. The joint F-test for *Income* is not significant when using median regression.

Models 4 and 5 evaluate income effects using the proportion of students from households with income less than 185 percent of the poverty line (*Eligible*). This is of particular interest because eligibility in the free or reduced lunch program is set at 185 percent of the poverty line. Model 4 estimates that a ten percentage point increase in *Eligible* decreases the number of entrees offered by 0.6 (Table 3.8). Although the data do not tell us how many eligible students actually participate and/or consume a school lunch, Model 4 suggests that districts with more eligible students offer fewer entrees.

Model 5 estimates the effect of *Eligible* on *Total Entrees* using dummy variables. All dummy variables are negative and together *Eligible* contributes to the number of entrees offered weekly (Table 3.9; Appendix E). School districts where 20 to 40 percent of students eligible for free or reduced lunch offer 2.4 fewer entrees per week than districts with less than 20 percent of eligible students (Table 3.9). The income effect is slightly larger when using conditional-median regression; the same school districts offer 3.0 fewer entrees per week (Model 7, Table 3.11).

In Model 5 and 7, districts with between 60 and 80 percent of students eligible for free or reduced meals offer a statistically equivalent number entrees per week than districts with 40 to 60 percent *Eligible.* This suggests that the additional \$0.02/meal subsidy given to "high-need" schools serving more than 60 percent free or reduced meals does not have an impact on the number of entrée offered weekly. Although we cannot directly compare these effects to those models using *Income* to measure district wealth, all models described above give evidence that the income level of the school district significantly impacts the number of entrees served. Additionally, there is evidence that the "high-need" subsidy does not increase the number of entrees offered weekly.

Three control variables are statistically significant in each income specification. First, school district enrollment has a positive effect on the number of entrees offered weekly, suggestive of economies of scale. Given the same per meal subsidy rate, larger districts may be able to produce a larger variety of entrees. Second, districts in states requiring a food service coordinator offer more entrees than districts in states without that requirement. It is possible that having someone responsible for coordinating food services district-wide increases efficiency and allows district to provide a larger number of entrees. Third, there are statistically significant differences in the number of entrees served in each region of the US. It is unclear whether this is due to regional differences in food access, preference, or something else.

Total Fruit

Results for *Total Fruit* are not as robust as the results for *Total Entrée*. The signs are as expected given the theory presented in Section IV (positive for *Income* coefficients, negative for *Eligible* coefficients), but not always statistically significant. As seen in Figure 3.6, a $10,000 increase in the median household income increases the number of fruits offered weekly, but the effect is not statistically different than zero. The estimated income effect using the natural log of income is positive and statistically significant: a ten percent increase in household income increases the number of fruits offered weekly by 0.02 (Table 3.7). Model 3 estimates income effects using income dummy variables. When the outcome variable is *Total Fruit*, the coefficients of the dummy variables are progressively larger with income. However, none are statistically significant and a joint F-test rejects the hypothesis that *Income* contributes to the number of fruits offered weekly (Table 3.8). Results are similar in Model 6 using conditional-median regression.

Evaluating income effects using *Eligible* as the measure of district income, a ten-percentage point increase decreases the number of fruits offered by 0.3 (Table 3.9). This suggests that districts with more eligible students (and thus, possibly a larger participation rate) offer fewer fruits. In support, estimates from Model 5 and 7 indicate that as the proportion of students from households with income less than 185 percent of the poverty line increases, the number of fruits offered weekly decrease, but not significantly.

Four control variables are consistently significant in all *Total Fruit* regressions. First, in all but Model 4, suburban school districts offer more fruits per week than urban school districts. Second, larger school districts (in terms of enrolled students) offer more fruits per week. This effect is smaller in magnitude than the marginal effect of enrollment on total entrees offered. Third, western states consistently offer the least amount of fruits per week. Lastly, October/November 2012 menus list fewer fruits than menus from August/September 2012 or April/May 2013.

Total Vegetable

The effect of income, measured at the county level (*Income*) or district level (*Eligible*), on the number of vegetables offered weekly is not significant in any models. However, when *Total Vegetables* is split into five vegetable subgroups, *Dark Green*, *Red/Orange*, *Legumes*, *Starchy*, and *Other*, *Income* does significantly impact the number of dark green and red/orange vegetables and legumes served (Appendix C). Model 2 suggests that a one-percent increase in household income increases the number of dark green vegetables offered weekly by 0.60. A joint F-test on the *Income* coefficients in Model 3 suggests that *Income* statistically contributes to the number of legumes offered each week (p-value=0.0883). Additionally, Model 4 indicates that a one-percentage point increase in the students eligible for free or reduced-price lunch reduces the number of red/orange vegetables offered by almost one.

Five control variables are consistently significant across all six *Total Vegetables* models. *Race* contributes to the number of vegetables offered per week. Specifically, an increase in the proportion of black and "other" students relative to white students decreases the number of vegetables offered. These results are not consistent if looking at vegetable subgroups (Appendix C). For example, districts with larger proportions of black students offer fewer red/orange vegetables but more dark green vegetables. Like with *Total Entrees* and *Total Fruit*, an increase in district enrollment increases the number of vegetables offered weekly. In addition, districts in the South offer more vegetables than northern districts. Overall, *Region* contributes to the number of vegetables offered.

Lastly, districts in states requiring or recommending schools offer two or more vegetables daily offer more vegetables per week.

VII. Conclusion

While controlling for school district racial profile, urbanicity, enrollment, region, education level of adults, and relevant food policies, household income does affect the composition of a NSLP reimbursable school lunch. There is strong evidence that wealthier districts offer elementary school students more entrée choices per week. There is weaker evidence that wealthier districts offer elementary school students more fruits and vegetable choices per week. In addition, schools with a higher proportion of students eligible to receive free- or reduced-price lunches offer elementary school students fewer entrée choices and fruit choices per week.

Children that are given more options at lunch are more likely to be exposed to foods they may not eat at home. If school food authorities are offering foods meeting the weekly meal patterns required of a reimbursable lunch, participating in the NSLP may increase access to healthy foods and improve participant's health outcomes. Moreover, students participating at school districts providing more than one fruit or vegetable are often able to select more than one of these items, likely increasing fruit and vegetable consumption. As discussed in the literature review, research on the relationship between childhood obesity and participation in the NSLP has had mixed results. This paper suggests one reason may be that while low-income students are more likely to participate in the NSLP and be obese, the NSLP menu is systematically different for schools in low-income areas.

The empirical section does not address the mechanism underlying these results. Section IV describes the various funding sources districts receive for provide school lunch for all students interested in participating. Federal funds make up the majority of the NSLP funding, but districts can choose to allocate other money as well. It may be that school districts in wealthier areas (or with wealthier students) are more likely to have additional funding available for school lunch, allowing SFAs to increase the food choices.

Increasing the availability of fruits and vegetables will contribute to the NSLP's aim to provide nutritious meals to school-aged children. The following policies may provide SFAs incentives to do so:

1. Increase NSLP funding to low-income schools. This can be achieved by increasing the "high-need" subsidy already given to SFAs serving more than 60 percent free- and reduced-priced meals. Alternatively or in conjunction with increasing the subsidy, the high-need cut off could be set at a lower rate.

2. Increase NSLP funding to smaller school districts. School districts with fewer students may be at a cost disadvantage because of the large fixed costs associated with food operations. Creating a lump-sum subsidy to small SFAs may allow districts to increase food storage capacity, update kitchen facilities, or provide training to food service personnel.

3. Create regional food service agreements. Small school districts may increase bargaining power by purchasing food in conjunction with other districts in the area.

It is unclear through this analysis whether or not elementary schools sampled are following the federal requirements of a reimbursable lunch, nor whether wealthy districts are providing healthier options than low-income school districts. Future research could evaluate the nutritional content of menu options to determine if they are equivalent across income levels. Future economic research examining the impact of participation in the NSLP on childhood health outcomes should be aware of the implicit (and perhaps incorrect) assumption that each student is provided a lunch of equal nutritional quality and quantity.

Table 3.1. Variables

Variable	Definition
Menu Level *From District & School Websites August 2012 – May 2013*	
Total Entrée	# entrées served per week
Total Fruit	# fruits served per week
Total Vegetable	# vegetables served per week
Green Vegetable	# dark green vegetables served per week
Red/Orange Vegetable	# red and orange vegetables served per week
Legume	# legumes served per week
Starchy Vegetable	# starchy vegetables served per week
Other Vegetable	# other vegetables served per week
Month1	Menu collected in August/September 2012 (Yes, No)
Month2	Menu collected in October/November 2012 (Yes, No)
Month3	Menu collected in April/May 2013 (Yes, No)
District Level *From Common Core Data (CCD) Survey 2010 – 2011*	
Eligible	Prop. students eligible for free/reduced price lunch
White	Prop. white, non-Hispanic enrolled students
Black	Prop. black, non-Hispanic enrolled students
Hispanic	Prop. Hispanic enrolled students
Other	Prop. other enrolled students
Urban	School located in urban area (Yes, No)
Suburban	School located in suburban area (Yes, No)
Rural	School located in rural area (Yes, No)
Enrollment	# enrolled students as of October 2010
County Level *From American Community Survey (ACS) 5-Yr Estimates 2006 - 2010*	
Income	Median Household Income in district's county/10,000
Attained BA	Prop. adults with Bachelor's degree or higher
State Level *From School Health Policies and Programs (SHPPS) 2006*	
North	School district located in the North (Yes, No)
Midwest	School district located in the Midwest (Yes, No)
South	School district located in the South (Yes, No)
West	School district located in the West (Yes, No)
Vending	State requires or recommends that schools prohibit access to vending machines (Require or Recommend, No Policy)
Coordinator	State requires each district provide a food service coordinator (Yes, No)

continued…

Table 3.1 (continued). Variables

Variable	Definition
Entrée Policy	State required or recommends that schools offer students a choice between 2 or more different lunch entrées daily. (Require or Recommend, No policy)
Fruit Policy	State required or recommends that schools offer students a choice between 2 or more different fruits daily. (Require or Recommend, No policy)
Vegetable Policy	State required or recommends that schools offer students a choice between 2 or more different vegetables daily. (Require or Recommend, No policy)

Notes: See Appendix A for vegetable classifications.

Table 3.2. District Demographics

Variable	Mean	Minimum	Maximum
Income	5.0664 (1.3021)	2.2948	11.9075
Eligible	0.46 (0.22)	0	0.99
Attained BA	0.26 (0.10)	0.08	0.58
Enrollment	18,189.13 (41,742.11)	69	667,273
Race			
White	0.62 (0.29)	0	0.99
Black	0.13 (0.20)	0	0.99
Hispanic	0.17 (0.22)	0	0.99
Other	0.08 (0.09)	0	0.97
Urbanicity			
Urban	0.25 (0.43)	0	1
Suburban	0.48 (0.50)	0	1
Rural	0.27 (0.44)	0	1
Region			
North	0.19 (0.39)	0	1
Midwest	0.27 (0.44)	0	1
South	0.32 (0.47)	0	1
West	0.22 (0.42)	0	1

Notes: Number of observations is 816. Standard deviations are in parentheses. See Table 3.3 for variable definitions.

Table 3.3. Descriptive Statistics

Variable	Mean	Minimum	Maximum
Total Entrée	12.04 (6.95)	5	45
Total Fruit	7.19 (4.28)	0	50
Total Vegetable	10.19 (4.81)	0	75
Green Vegetable	1.04 (1.18)	0	10
Red/Orange Vegetable	1.64 (1.49)	0	11
Legume	1.04 (1.07)	0	20
Starchy Vegetable	1.97 (1.31)	0	15
Other Vegetable	1.25 (1.33)	0	11
Vending	0.52 (0.50)	0	1
Coordinator	0.34 (0.47)	0	1
Entrée Policy	0.52 (0.50)	0	1
Fruit Policy	0.41 (0.49)	0	1
Vegetable Policy	0.39 (0.49)	0	1
Month			
Month1 (Aug/Sept 2012)	0.13 (0.33)	0	1
Month2 (Oct/Nov 2012)	0.18 (0.39)	0	1
Month3 (Apr/May 2013)	0.69 (0.46)	0	1

Notes: Number of observations is 816. Standard deviations are in parentheses. See Table 3.3 for variable definitions.

Table 3.4. Variety of Vegetables Offered Weekly

	Percent of Total Vegetables	Percent of Subgroup
Vegetable Subgroup		
Dark Green	10.1	-
Red/Orange	15.4	-
Legume	10.1	-
Starchy	20.2	-
Other	11.6	-
Combination	6.4	-
Uncategorized	26.2	-
Specific Vegetable (Subgroup)		
Broccoli (Green)	5.5	62.5
Carrot (Red/Orange)	9.8	63.2
Baked Beans (Legume)	3.4	35.3
Corn (Starchy)	5.6	30.4
Potato (Starchy)	12.2	59.4
Green Beans (Other)	5.4	53.3

Notes: Number of observations is 810. Combination vegetables include vegetables from more than one subgroup (e.g. “Peas and Carrots”). Uncategorized vegetables could not be defined from the menu (e.g. “Vegetable” or “Salad”). See Appendix A for other vegetable definitions. “Potato” includes potato products, such as French fries.

Table 3.5. Model 1, Income Polynomial

	(1) Entree	(2) Fruit	(3) Vegetable
Income	6.347*	1.730	1.588
	(3.207)	(2.197)	(2.462)
Income^2	-1.044*	-0.190	-0.281
	(0.500)	(0.345)	(0.386)
Income^3	0.062*	0.008	0.018
	(0.024)	(0.017)	(0.020)
Attained BA	2.133	-3.330	-0.523
	(3.566)	(2.435)	(2.917)
Race (White Omitted)			
Black	-2.196	0.338	-2.579**
	(1.180)	(0.765)	(0.810)
Hispanic	-0.698	-0.869	-1.396
	(1.433)	(0.702)	(0.756)
Other	-1.412	-1.495	-4.242**
	(2.549)	(1.379)	(1.461)
Urbanicity (Urban Omitted)			
Suburban	0.338	0.875*	0.038
	(0.624)	(0.420)	(0.426)
Rural	-0.891	0.570	0.850
	(0.801)	(0.581)	(0.600)
ln(Enrollment)	1.085***	0.543***	0.532***
	(0.185)	(0.124)	(0.134)
Region (North Omitted)			
Midwest	-4.655***	-0.390	0.690
	(0.885)	(0.542)	(0.511)
South	-4.765***	-0.425	2.178**
	(0.996)	(0.664)	(0.702)
West	-5.684***	-1.076*	-0.615
	(0.976)	(0.532)	(0.544)
Vending	-1.086*	-0.191	-0.532
	(0.540)	(0.301)	(0.355)
Coordinator	1.851*	0.532	-0.261
	(0.744)	(0.484)	(0.582)

continued…

Table 3.5 (continued). Model 1, Income Polynomial

	(1) Entree	(2) Fruit	(3) Vegetable
Food Policy	0.370	0.369	0.762*
	(0.536)	(0.276)	(0.334)
Month (Month1 Omitted)			
Month2	1.177	-1.351*	-0.527
	(0.855)	(0.616)	(0.588)
Month3	1.389	-1.040	-0.357
	(0.738)	(0.563)	(0.531)
Constant	-8.239	-0.670	2.850
	(6.696)	(4.313)	(5.109)
R^2	0.212	0.074	0.087

Notes: The number of observations for each regression is 816. Robust standard errors are in parentheses. *, **, *** indicate significance at α = 10%, 5% and 1%, respectively. Food Policy is *Entrée Policy* when *Total Entrees* is the outcome variable, *Fruit Policy* for *Total Fruit* and *Vegetable Policy* for *Total Vegetables*. Joint F-tests for *Income*, *Race*, *Urbanicity*, *Region* and *Month* provided in Appendix E.

Table 3.6. Model 2, Natural Log of Income

	(1) Entree	(2) Fruit	(3) Vegetable
LnIncome	4.834**	2.204*	1.201
	(1.588)	(1.083)	(1.189)
Attained BA	2.685	-3.311	-0.353
	(3.552)	(2.429)	(2.924)
Race (White Omitted)			
Black	-2.191	0.315	-2.563**
	(1.185)	(0.762)	(0.791)
Hispanic	-0.664	-0.870	-1.366
	(1.436)	(0.701)	(0.752)
Other	-0.931	-1.546	-4.026**
	(2.478)	(1.368)	(1.386)
Urbanicity (Urban Omitted)			
Suburban	0.471	0.872*	0.087
	(0.619)	(0.420)	(0.423)
Rural	-0.784	0.564	0.888
	(0.792)	(0.572)	(0.585)
ln(Enrollment)	1.081***	0.546***	0.528***
	(0.185)	(0.124)	(0.135)
Region (North Omitted)			
Midwest	-4.518***	-0.373	0.742
	(0.889)	(0.519)	(0.510)
South	-4.439***	-0.422	2.311***
	(1.006)	(0.666)	(0.688)
West	-5.656***	-1.064*	-0.604
	(0.976)	(0.516)	(0.537)
Vending	-1.042	-0.191	-0.519
	(0.541)	(0.300)	(0.354)
Coordinator	1.832*	0.533	-0.275
	(0.746)	(0.485)	(0.582)
Month (Month1 Omitted)			
Month2	1.227	-1.352*	-0.512
	(0.859)	(0.617)	(0.588)
Month3	1.472*	-1.040	-0.331
	(0.742)	(0.564)	(0.531)

continued…

Table 3.6 (continued). Model 2, Natural Log of Income

	(1) Entree	(2) Fruit	(3) Vegetable
Food Policy	0.410	0.371	0.806*
	(0.539)	(0.274)	(0.330)
Constant	-47.486**	-19.647	-7.116
	(16.363)	(11.125)	(12.387)
R^2	0.203	0.074	0.085

Notes: The number of observations for each regression is 816. Robust standard errors are in parentheses. *, **, *** indicate significance at α = 10%, 5% and 1%, respectively. Food Policy is *Entrée Policy* when *Total Entrees* is the outcome variable, *Fruit Policy* for *Total Fruit* and *Vegetable Policy* for *Total Vegetables*. Joint F-tests for *Income*, *Race*, *Urbanicity*, *Region* and *Month* provided in Appendix E.

Table 3.7. Model 3, Income Dummy Variables

	(1) Entree	(2) Fruit	(3) Vegetable
Income Dummy (<=3.5 Omitted)			
Income > 3.5	0.645	0.256	-0.377
	(0.859)	(0.596)	(0.591)
Income > 4.5	0.888	0.747	0.586
	(0.548)	(0.410)	(0.487)
Income > 5.5	0.428	0.222	-0.419
	(0.772)	(0.512)	(0.520)
Income > 6.5	1.666	0.230	0.275
	(1.054)	(0.570)	(0.596)
Attained BA	4.099	-2.625	1.064
	(3.496)	(2.233)	(2.618)
Race (White Omitted)			
Black	-2.329	0.288	-2.706***
	(1.226)	(0.775)	(0.819)
Hispanic	-0.604	-0.923	-1.502
	(1.456)	(0.739)	(0.774)
Other	-1.294	-1.391	-4.038**
	(2.649)	(1.412)	(1.424)
Urbanicity (Urban Omitted)			
Suburban	0.538	0.922*	0.153
	(0.629)	(0.420)	(0.415)
Rural	-0.689	0.615	0.947
	(0.809)	(0.573)	(0.599)
ln(Enrollment)	1.117***	0.549***	0.541***
	(0.185)	(0.121)	(0.135)
Region (North Omitted)			
Midwest	-4.545***	-0.431	0.682
	(0.873)	(0.514)	(0.499)
South	-4.452***	-0.384	2.330***
	(0.999)	(0.642)	(0.681)
West	-5.657***	-1.096*	-0.628
	(0.967)	(0.500)	(0.533)
Vending	-1.064*	-0.210	-0.537
	(0.534)	(0.307)	(0.357)

continued…

Table 3.7 (continued). Model 3, Income Dummy Variables

	(1) Entree	(2) Fruit	(3) Vegetable
Coordinator	1.725*	0.478	-0.359
	(0.742)	(0.489)	(0.578)
Month (Month1 Omitted)			
Month2	1.207	-1.349*	-0.501
	(0.863)	(0.620)	(0.587)
Month3	1.492*	-1.029	-0.331
	(0.750)	(0.564)	(0.531)
Food Policy	0.369	0.345	0.780*
	(0.537)	(0.280)	(0.335)
Constant	2.592	3.170*	5.489***
	(2.412)	(1.355)	(1.472)
R^2	0.202	0.075	0.086

Notes: The number of observations for each regression is 816. Robust standard errors are in parentheses. *, **, *** indicate significance at α = 10%, 5% and 1%, respectively. Food Policy is *Entrée Policy* when *Total Entrees* is the outcome variable, *Fruit Policy* for *Total Fruit* and *Vegetable Policy* for *Total Vegetables*. Joint F-tests for *Income*, *Race*, *Urbanicity*, *Region* and *Month* provided in Appendix E.

Table 3.8. Model 4, Eligible

	(1) Entree	(2) Fruit	(3) Vegetable
Eligible	-5.911***	-2.507*	-1.764
	(1.690)	(1.000)	(0.909)
Attained BA	5.393	-1.907	0.068
	(3.007)	(1.740)	(2.035)
Race (White Omitted)			
Black	0.132	1.275	-1.834*
	(1.366)	(0.914)	(0.900)
Hispanic	1.950	0.242	-0.588
	(1.636)	(0.859)	(0.791)
Other	0.001	-1.139	-3.761**
	(2.369)	(1.409)	(1.352)
Urbanicity (Urban Omitted)			
Suburban	0.351	0.833	0.033
	(0.640)	(0.425)	(0.419)
Rural	-0.704	0.614	0.889
	(0.805)	(0.580)	(0.611)
ln(Enrollment)	1.098***	0.558***	0.527***
	(0.182)	(0.123)	(0.142)
Region (North Omitted)			
Midwest	-4.699***	-0.463	0.718
	(0.881)	(0.500)	(0.484)
South	-4.410***	-0.429	2.347***
	(0.995)	(0.650)	(0.694)
West	-5.819***	-1.142*	-0.625
	(0.968)	(0.495)	(0.539)
Vending	-1.202*	-0.275	-0.561
	(0.537)	(0.298)	(0.366)
Coordinator	1.430*	0.352	-0.388
	(0.719)	(0.475)	(0.583)
Month (Month1 Omitted)			
Month2	1.087	-1.404*	-0.561
	(0.851)	(0.611)	(0.581)
Month3	1.292	-1.113*	-0.387
	(0.746)	(0.566)	(0.530)

continued…

Table 3.8 (continued). Model 4, Eligible

	(1) Entree	(2) Fruit	(3) Vegetable
Food Policy	0.335	0.355	0.808*
	(0.536)	(0.280)	(0.340)
Constant	6.286*	4.716**	6.445***
	(2.720)	(1.479)	(1.505)
R^2	0.207	0.076	0.086

Notes: The number of observations for each regression is 816. Robust standard errors are in parentheses. *, **, *** indicate significance at α = 10%, 5% and 1%, respectively. Food Policy is *Entrée Policy* when *Total Entrees* is the outcome variable, *Fruit Policy* for *Total Fruit* and *Vegetable Policy* for *Total Vegetables*. Joint F-tests for *Income*, *Race*, *Urbanicity*, *Region* and *Month* provided in Appendix E.

Table 3.9. Model 5, Eligible Dummy Variables

	(1) Entree	(2) Fruit	(3) Vegetable
Eligible Dummy (<= 0.20 Omitted)			
Eligible > 0.20	-2.417**	-0.198	0.348
	(0.866)	(0.496)	(0.533)
Eligible > 0.40	-0.232	-0.872	-1.012
	(0.608)	(0.506)	(0.582)
Eligible > 0.60	-0.233	-0.114	-0.195
	(0.693)	(0.459)	(0.428)
Eligible > 0.80	-0.814	-0.235	0.034
	(0.920)	(0.595)	(0.544)
Attained BA	7.330*	-1.732	-0.172
	(2.963)	(1.782)	(2.229)
Race (White Omitted)			
Black	-1.253	0.863	-2.021*
	(1.512)	(1.030)	(0.908)
Hispanic	0.709	-0.075	-0.684
	(1.720)	(0.923)	(0.866)
Other	-0.764	-1.214	-3.663**
	(2.402)	(1.493)	(1.370)
Urbanicity (Urban Omitted)			
Suburban	0.592	0.828*	-0.036
	(0.638)	(0.422)	(0.432)
Rural	-0.399	0.567	0.759
	(0.812)	(0.589)	(0.578)
ln(Enrollment)	1.168***	0.570***	0.527***
	(0.186)	(0.127)	(0.136)
Region (North Omitted)			
Midwest	-4.499***	-0.487	0.619
	(0.895)	(0.522)	(0.491)
South	-4.324***	-0.430	2.317***
	(1.001)	(0.670)	(0.700)
West	-5.596***	-1.134*	-0.682
	(0.978)	(0.511)	(0.547)

continued…

Table 3.9 (continued). Model 5, Eligible Dummy Variables

	(1) Entree	(2) Fruit	(3) Vegetable
Vending	-1.159*	-0.325	-0.634
	(0.541)	(0.307)	(0.377)
Coordinator	1.447*	0.426	-0.297
	(0.720)	(0.481)	(0.579)
Month (Month1 Omitted)			
Month2	1.153	-1.354*	-0.516
	(0.854)	(0.609)	(0.591)
Month3	1.371	-1.093	-0.382
	(0.742)	(0.563)	(0.537)
Food Policy	0.286	0.362	0.813*
	(0.532)	(0.278)	(0.336)
Constant	4.824	4.272**	6.218***
	(2.542)	(1.469)	(1.477)
R^2	0.207	0.076	0.090

Notes: The number of observations for each regression is 816. Robust standard errors are in parentheses. *, **, *** indicate significance at α = 10%, 5% and 1%, respectively. Food Policy is *Entrée Policy* when *Total Entrees* is the outcome variable, *Fruit Policy* for *Total Fruit* and *Vegetable Policy* for *Total Vegetables*. Joint F-tests for *Income*, *Race*, *Urbanicity*, *Region* and *Month* provided in Appendix E.

Table 3.10. Model 6, Median Regression using *Income*

	(1) Entrée	(2) Fruit	(3) Vegetable
Income Dummy (<=3.5 Omitted)			
Income > 3.5	0.610	0.254	-0.110
	(0.892)	(0.431)	(0.527)
Income > 4.5	0.520	0.129	0.074
	(0.619)	(0.183)	(0.348)
Income > 5.5	1.131	0.341	-0.053
	(0.940)	(0.478)	(0.359)
Income > 6.5	-0.122	-0.448	0.124
	(1.279)	(0.590)	(0.465)
Attained BA	4.417	0.194	2.768
	(4.542)	(1.207)	(2.002)
Race (White Omitted)			
Black	-1.861	0.403	-1.429
	(1.254)	(0.615)	(0.851)
Hispanic	-1.722	0.124	-0.100
	(1.261)	(0.425)	(0.636)
Other	0.824	0.326	-2.111
	(3.852)	(0.623)	(1.423)
Urbanicity (Urban Omitted)			
Suburban	0.461	0.507	0.558
	(0.725)	(0.386)	(0.353)
Rural	-0.046	0.411	0.545
	(0.906)	(0.362)	(0.499)
ln(Enrollment)	1.541***	0.139	0.189
	(0.176)	(0.120)	(0.122)
Region (North Omitted)			
Midwest	-3.880***	-0.588	1.063**
	(1.175)	(0.536)	(0.367)
South	-4.139***	-0.679	1.942***
	(1.248)	(0.660)	(0.585)
West	-5.162***	-0.838	-0.514
	(1.190)	(0.550)	(0.524)

continued…

Table 3.10 (continued). Model 6, Median Regression using *Income*

	(1) Entrée	(2) Fruit	(3) Vegetable
Vending	-0.607	-0.095	0.094
	(0.587)	(0.164)	(0.239)
Coordinator	1.624*	0.408	-0.146
	(0.755)	(0.380)	(0.426)
Food Policy	-0.169	0.178	0.557*
	(0.528)	(0.245)	(0.262)
Month (Month1 Omitted)			
Month2	1.413	-2.820*	-0.511
	(1.000)	(1.211)	(0.479)
Month3	1.836*	-2.707*	-0.791
	(0.929)	(1.229)	(0.431)
Constant	-2.693	6.571**	6.941***
	(2.695)	(2.253)	(1.344)
R^2	0.115	0.0222	0.0451

Notes: The number of observations for each regression is 816. Bootstrapped standard errors (400 replications) are in parentheses. *, **, *** indicate significance at α = 10%, 5% and 1%, respectively. Food Policy is *Entrée Policy* when *Total Entrees* is the outcome variable, *Fruit Policy* for *Total Fruit* and *Vegetable Policy* for *Total Vegetables*. Joint F-tests for *Income*, *Race*, *Urbanicity*, *Region* and *Month* provided in Appendix E.

Table 3.11. Model 7, Median Regression using *Eligible*

	(1) Entrée	(2) Fruit	(3) Vegetable
Eligible Dummy (<= 0.20 Omitted)			
Eligible > 0.20	-3.003*	-0.044	-0.021
	(1.293)	(0.460)	(0.327)
Eligible > 0.40	-0.284	-0.179	-0.515
	(0.637)	(0.294)	(0.327)
Eligible > 0.60	-1.201	-0.155	-0.149
	(0.872)	(0.253)	(0.327)
Eligible > 0.80	-0.334	-0.081	0.071
	(1.006)	(0.288)	(0.677)
Attained BA	4.646	-0.516	1.705
	(3.373)	(1.085)	(1.611)
Race (White Omitted)			
Black	0.880	0.879	-0.831
	(1.636)	(0.717)	(0.988)
Hispanic	1.428	0.237	0.402
	(1.861)	(0.597)	(0.799)
Other	1.685	-0.032	-2.319
	(3.136)	(0.642)	(1.375)
Urbanicity (Urban Omitted)			
Suburban	0.602	0.391	0.378
	(0.777)	(0.355)	(0.386)
Rural	0.128	0.325	0.330
	(0.962)	(0.347)	(0.463)
ln(Enrollment)	1.425***	0.163	0.166
	(0.204)	(0.134)	(0.121)
Region (North Omitted)			
Midwest	-2.954**	-0.635	0.917*
	(1.133)	(0.522)	(0.395)
South	-3.420**	-0.613	1.901**
	(1.178)	(0.598)	(0.595)
West	-4.758***	-0.761	-0.530
	(1.137)	(0.531)	(0.542)

continued…

Table 3.11 (continued). Model 7, Median Regression using *Eligible*

	(1) Entrée	(2) Fruit	(3) Vegetable
Vending	-0.663	-0.040	0.066
	(0.570)	(0.180)	(0.273)
Coordinator	1.516*	0.414	-0.049
	(0.743)	(0.391)	(0.448)
Food Policy	0.071	0.135	0.693**
	(0.563)	(0.247)	(0.248)
Month (Month1 Omitted)			
Month2	1.264	-2.858*	-0.514
	(0.907)	(1.154)	(0.481)
Month3	1.781*	-2.755*	-0.729
	(0.779)	(1.176)	(0.415)
Constant	0.722	7.152***	7.572***
	(2.988)	(2.057)	(1.397)
R^2	0.1186	0.0225	0.046

Notes: The number of observations for each regression is 816. Bootstrapped standard errors (400 replications) are in parentheses. *, **, *** indicate significance at α = 10%, 5% and 1%, respectively. Food Policy is *Entrée Policy* when *Total Entrees* is the outcome variable, *Fruit Policy* for *Total Fruit* and *Vegetable Policy* for *Total Vegetables*. Joint F-tests for *Income*, *Race*, *Urbanicity*, *Region* and *Month* provided in Appendix E.

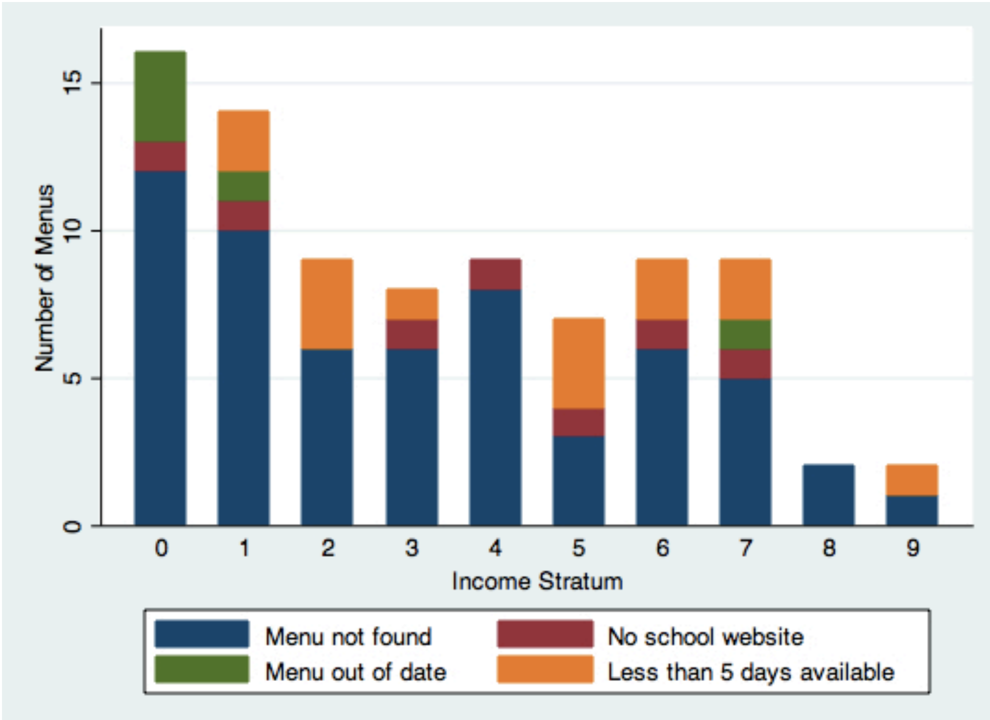

Figure 3.1. Data Collection Issues by Income Strata

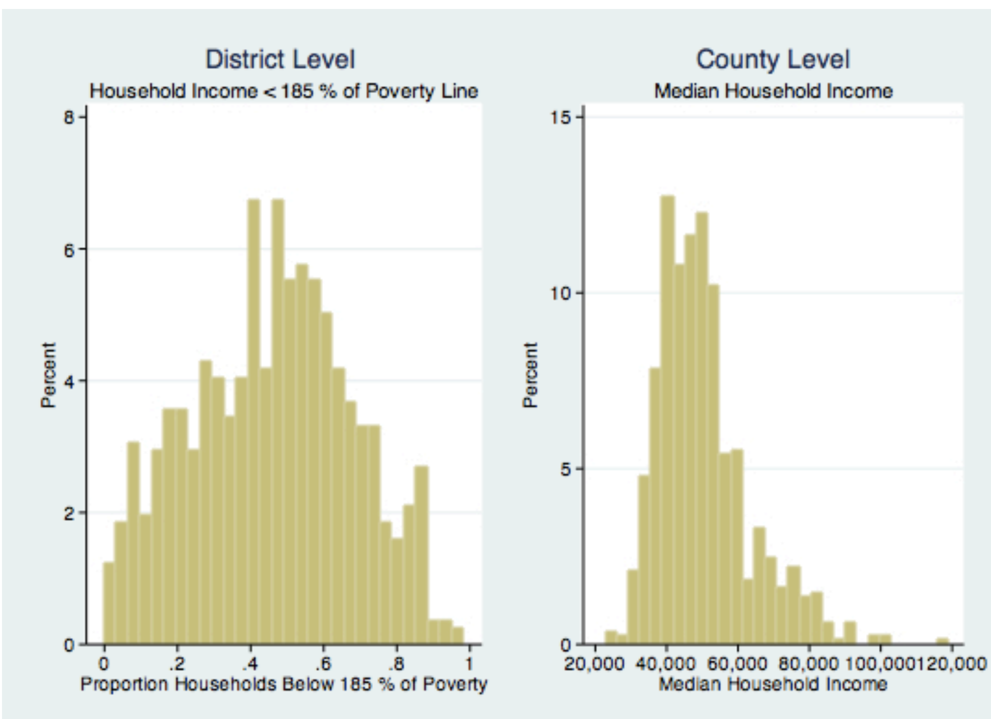

Figure 3.2. Measuring Income

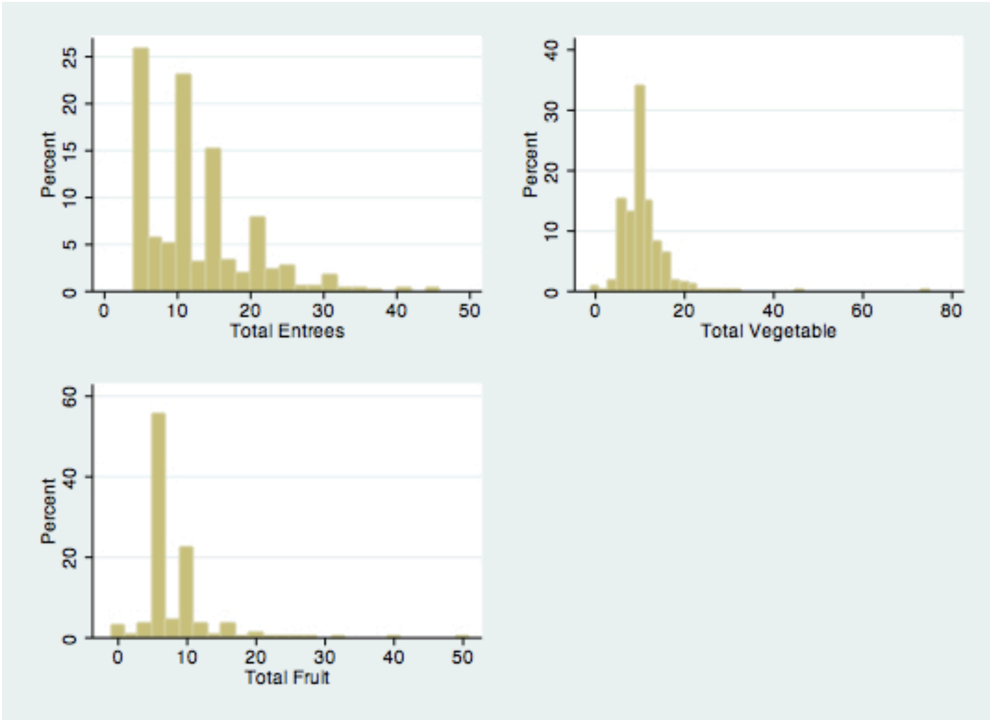

Figure 3.3. Histogram of Outcome Variables

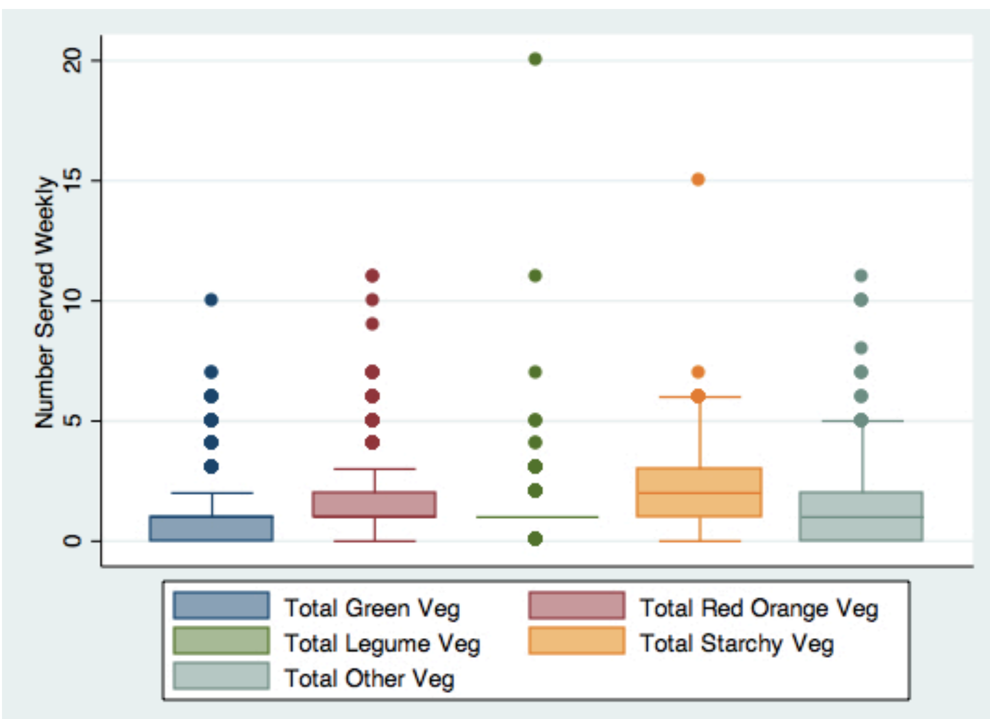

Figure 3.4. Distribution of Vegetable Subgroups

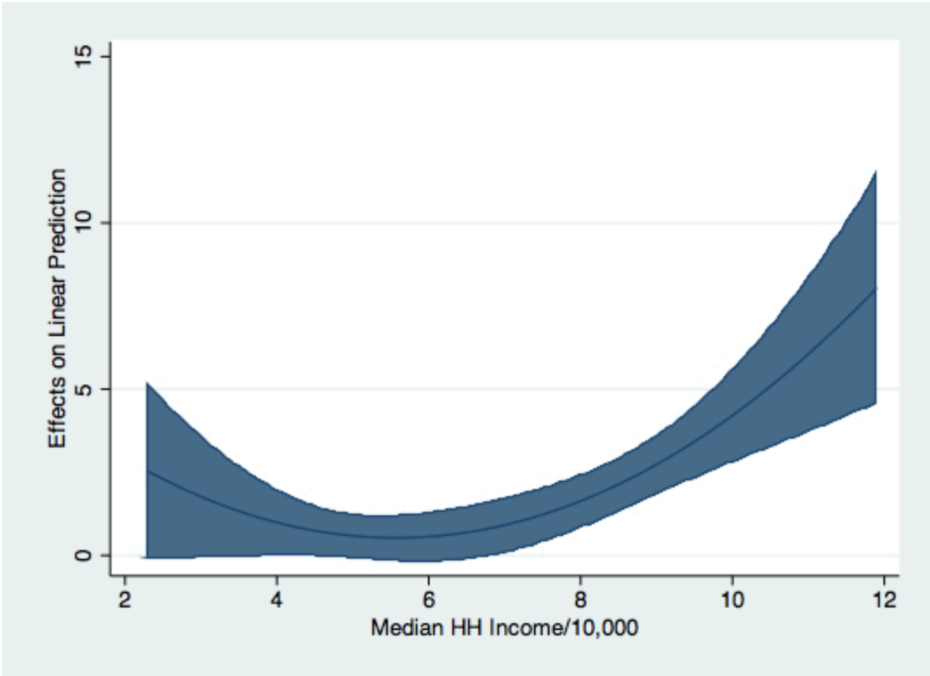

Figure 3.5. Marginal Effect of Median County Income on Number of Entrees Offered Weekly

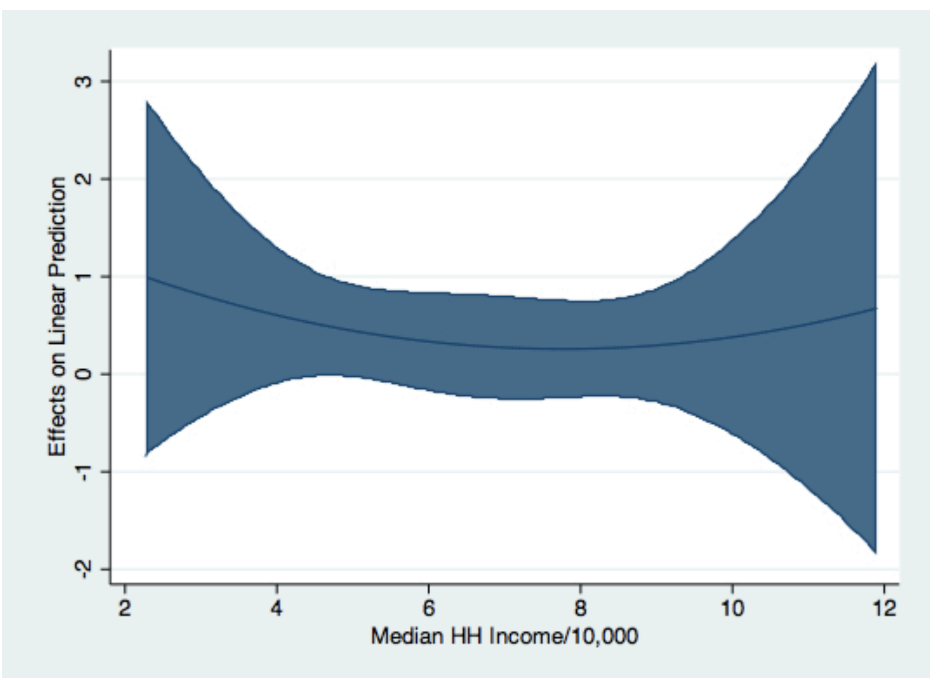

Figure 3.6. Marginal Effect of Median County Income on Number of Fruits Offered Weekly

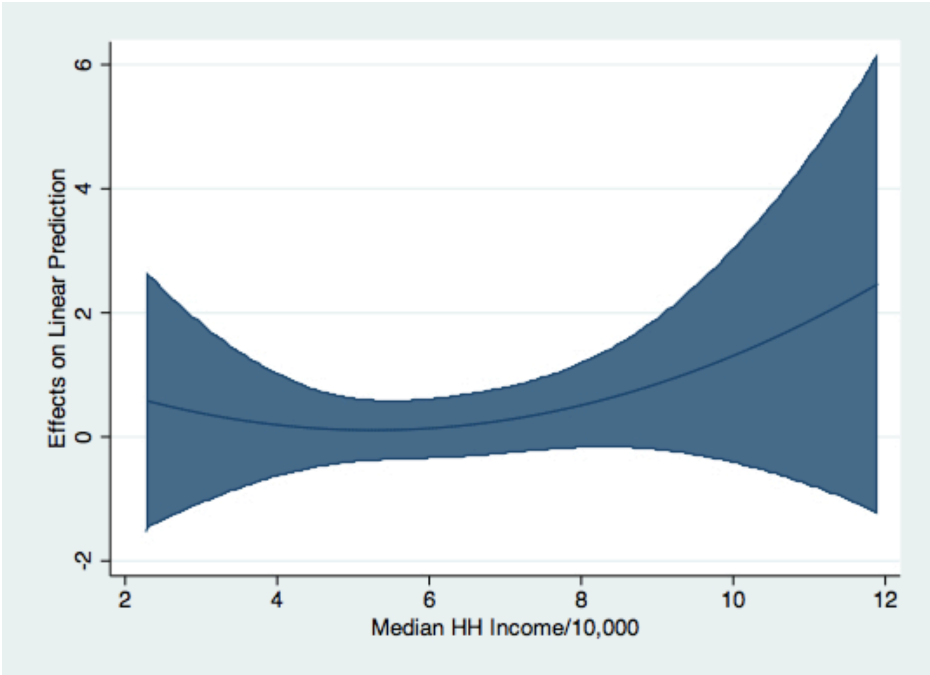

Figure 3.7. Marginal Effect of Median County Income on Number of Vegetables Offered Weekly

CHAPTER FOUR

DOES INCOME EFFECT STUDENTS' CHOICE OF ENTRÉE WITHIN NATIONAL SCHOOL LUNCH PROGRAM MENUS?

Introduction

The National School Lunch Program (NSLP) is one of the largest nutrition assistance programs in the United States, providing free and reduced-price lunches for income-eligible students as well as minimally subsidizing paid lunches for students that do not qualify to receive free or reduce-price lunches. In 2011, over five billion lunches were served to an average of 31.7 million students per day (U.S. Department of Agriculture 2012). When the program was introduced in 1946, the 'Type A' qualifying lunch offered was designed to provide one-third to one-half of the daily food requirements of a ten- to twelve-year-old child (Ralston et al. 2008). As nutritional knowledge progressed over time, the Type A lunch was updated to reflect these advancements. New guidelines effective beginning in the 2012/13 school year align the required food components of a Type A lunch provided by the NSLP with the 2005 Dietary Guidelines for Americans as required by the Richard B. Russell National School Lunch Act (U.S. Department of Agriculture 2012). Specifically, the new guidelines increase the availability of healthful foods (fruits, vegetables, and whole grains), while reducing the levels of sodium and saturated fats and controlling calorie levels of the offered items. Although schools that offer the National School Lunch Program (NSLP) must adhere to the United States Department of Agriculture's guidelines regarding menu offerings, individual schools have the ability to select the components offered on any particular day and generally offer several entrée options. The offerings at a given school on a particular day generally differ in the nutritional content and healthfulness.

In this study, we investigate the relationship between income-eligibility status (Free, Reduced, or Paid) and entrée selection. As previously indicated, some NSLP participants are eligible to receive free lunches, others pay a reduced-cost, and some pay the full-price. Specifically, students from households with income below or equal to 130 percent of the poverty line are eligible to receive free lunches, while students from households with household incomes between 130 percent and 185 percent of the poverty line are eligible to receive reduced-price lunches; roughly 69 percent of all lunches served are free or reduced-price lunches (Food and Nutrition Service 2013a). Students from households with household incomes exceeding 185 percent of the poverty line are income-ineligible to receive free or reduced-price lunches, but may purchase "full-price" lunches.[20] Thus the nutritional standards of the NSLP may impact children at all income levels.

Previous research investigating the healthfulness of the NSLP is mixed. Recent studies have found positive correlation between participation in the NSLP and child weight (Millimet, Tchernis, & Husain 2010; Schanzenbach 2009) and energy consumption (Campbell et al. 2011). Gleason and Suitor (2003) estimate that at lunch, NSLP participants on average consumed ninety-five percent more sodium than recommended

[20] In 2012, the poverty line for a family of four was $23,050 (U.S. Department of Agriculture 2012).

while non-participants consumed eighty-eight percent more sodium than recommended. The authors also find that relative to non–participants (students presumably bringing lunch from home), NSLP participants consume more dietary fat as a percentage of calories. A recent study by Hanson and Olson (2013) compares the dietary intake of low-income NSLP participants and high-income NSLP participants. The authors find that while all participants consumed more saturated fats and sodium than non-participants, high-income participants had lower saturated fat intake than low-income NSLP participants.

The majority of research concludes that NSLP participants consume more fats and sodium than non-participants, which may lead to higher rates of overweight and obesity. This is particularly concerning since low-income minorities are both at greater risk for obesity and more likely to participate in the NSLP, creating the potential for positive selection bias (Ogden & Carroll 2010). Furthermore, differences across income in dietary intake among NSLP participants may be an underlying cause of the previous mixed results. Using a unique dataset tracking daily entrée choices among students from eleven suburban elementary schools in South Carolina, this paper provides a novel approach to understanding the healthfulness of the NSLP.

Using a conditional logit model, we determine whether the nutritional content of an entrée affects the likelihood of selecting that entrée and whether the likelihood is different across income-eligibility status. Using ordinary least squares regression, we determine whether students of different income-eligibility, grade levels, gender, or race systematically make different choices at lunch. We find that students receiving free, reduced-, or paid-price meals prefer entrees with more fat, sodium, and protein. Income-eligibility does affect a student's choice of entrée: students receiving free lunches are more likely to select entrees with more fat and carbohydrates and less protein than students purchasing paid-price lunches. While the new NSLP guidelines aim to reduce the fat and sodium content of all school lunches offered, students prefer these qualities in their foods. In order to better understand the nutritional content actually consumed, implementing a school-wide nutritional education curriculum may be necessary.

Theory and Methods

Each school district participating in the National School Lunch Program creates a lunch menu following the guidelines for a reimbursable lunch set by the USDA. As of July 2012, the federal guidelines for kindergarten through fifth grade require participating schools to offer at least one option for each of the five meal components each day. The five meal components that must be offered daily are: 1) meat or meat alternative, 2) bread or grain, 3) fruit, 4) vegetable, and 5) milk (U.S. Department of Agriculture 2012). Total calories per lunch must fall between 550 and 650kcal, and, beginning in the school year 2014/15, total sodium can be no greater than 640mg per lunch. Districts were given more time to meet the new sodium guidelines because it will be challenging for many of the existing vendors and suppliers may need to modify their products to meet these standards. For a summary of all federal guidelines, see Appendix A. In addition to the federal guidelines, South Carolina requires that each school offer at least two different entrees and vegetables and recommends each school offers two or more fruits (Center for Disease Control and Prevention 2007).

The sampled school district's Food and Nutrition Services Department creates monthly school lunch menus that meet federal and state guidelines for a reimbursable lunch. Students and parents can access school lunch menus on-line and menus are also sent home with each student on a monthly basis. Thus caregivers and students are aware of what is being served for lunch in the school cafeteria and can use this information when deciding to buy a school lunch or bring one from home. On a typical day, a student has three entrée choices, two fruit options, two vegetable options, and milk options to choose from (see Appendix F for an example of a monthly menu). In order to be considered a qualifying lunch (in which the school is reimbursed by the government), a student must select a minimum of three items, one of which must be a fruit or vegetable. Given the POS data available, the analysis focuses on a student's choice of entrée.

Each student obtains a level of utility from each entrée j served. We assume a student's utility is a function of nutritional qualities of the entrée: calories, fat, sodium, protein, and carbohydrates. Consider a student choosing between a turkey sandwich, chicken nuggets, and the vegetarian tray (string cheese, yogurt, and graham crackers). The student chooses the turkey sandwich if he prefers it to the other two options. The nutritional qualities of the entrée directly or indirectly determine his preferences: he chooses the turkey sandwich because he wants the option with the lowest amount of fat (and fat directly determines preference) or he likes the option that tastes best (and fat indirectly determines preference).

Let choice set C_i be all entrée options available to student *i* on a given day. The student chooses the entrée that maximizes utility U_{ij} such that the probability of selecting entrée *j* is the probability that the utility from that entrée is greater than utility received from any other entrée available:

$$(4.1) \quad P_i\left(j \middle| C_i\right) = \Pr\left(U_{ij} > U_{ik} \quad \forall\ k \in C_i,\ k \neq j\right)$$

where

$$0 \leq P\left(j \middle| C_i\right) \leq 1 \quad \forall\ \mathrm{j} \in \mathrm{C}_i$$
$$\sum_{j \in C_i} P\left(j \middle| C_i\right) = 1$$

Thus, only differences in utility level among choices matter, not the absolute level of utility. The level of utility is determined by $\mathbf{N}'_{ij}$, a vector of observed nutritional characteristics of each entrée (*Calories*, *Fat*, *Sodium*, *Protein*, and *Carbohydrates*) and a stochastic component, ϵ_{ij}. Given a linear utility function, the utility function for the i^{th} student choosing entrée *j* is $U_{ij} = \mathbf{N}'_{ij}\beta + \varepsilon_{ij}$ for all *j* in the choice set C_i.

Model 1

The conditional logit model is consistent with the utility maximizing behavior described in the random utility model above if the error term is identically and independently Gumbel-distributed, $F\left(\varepsilon_{ij}\right) = \exp\left(-e^{-\varepsilon_{ij}}\right)$. We use this model to estimate how the nutritional content of an entrée affects the likelihood that an average student will select the entrée. The likelihood function of the conditional logit is

$$\text{(4.2)} \quad LF = \prod_{i=1}^{n} \prod_{j \in C_i}^{C_i} \left[\frac{\exp\left(\mathbf{N}'_{ij}\beta\right)}{\sum_{k=1}^{J} \exp\left(\mathbf{N}'_{ik}\beta\right)} \right]^{y_{ij}} .$$

where y_{ij} is 1 if student i chooses entrée j and 0 otherwise. The assumption in this model is that the choice set C_i only includes the three daily entrées offered at the cafeteria. This part of the analysis examines POS data and excludes students bringing lunch from home.

Model 2

Second, we assume that if there is no POS data for student i on a given day, that student has brought a lunch from home and thus C_i includes a fourth generic entrée choice: "Home Lunch." This approach assumes that each student either purchases a lunch or brings one from home and does not account for the possibility of a student being absent or not eating lunch. Because the true nutritional information for "Home Lunch" is unknown, so we assume it has the nutrition content of the average school lunch purchased.[21] A dummy variable indicating whether a lunch is purchased at school or assumed to be brought from home is included in this second model. Let *Home*=0 when student i purchases any entrée at school and *Home*=1 when student i bring a lunch from home. The likelihood ratio is

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[21] See the weighted average calories, fat, sodium, protein, and carbohydrates in Appendix G.

(4.3) $$LF = \prod_{i=1}^{n} \prod_{j \in C_i}^{C_i} \left[\frac{\exp\left(\alpha Home_{ij} + \mathbf{N}'_{ij}\beta\right)}{\sum_{k=1}^{J} \exp\left(\alpha Home_{ik} + \mathbf{N}'_{ik}\beta\right)} \right]^{y_{ij}} .$$

Model 3

The conditional logit model can also illuminate differences across income-eligibility status (Free, Reduced, or Paid). In the final model, all nutritional characteristics in $\mathbf{N}'_{ij}$ are interacted with income-eligibility status to observe differences across our proxy for family income in the new vector $\mathbf{I}'_{ij}\delta$. Let the likelihood ratio be

(4.4) $$LF = \prod_{i=1}^{n} \prod_{j \in C_i}^{C_i} \left[\frac{\exp\left(\alpha Home_{ij} + \mathbf{N}'_{ij}\beta + \mathbf{I}'_{ij}\delta\right)}{\sum_{k=1}^{J} \exp\left(\alpha Home_{ik} + \mathbf{N}'_{ik}\beta + \mathbf{I}'_{ik}\delta\right)} \right]^{y_{ij}} .$$

The choice set C_i in this model includes three entrees served and the option of choosing a lunch from home.

Ordinary Least Squares Regression

Ordinary least squares regression (OLS) is used to determine whether income, grade level, gender, school location or race impacts the nutritional value of the chosen entrée. Let Y_j be the total nutrient value in the j^{th} entrée purchased

(4.5) $$Y_j = \alpha_j + \mathbf{x}'_j\beta + School'_j\delta + \varepsilon_j$$

The model is estimated once for each nutrient in the dataset: Calories, Fat, Sodium, Protein, and Carbohydrates. The model includes categorical variables for *Race*, *Status*, *Gender*, *School*, and *Grade*. The vector $\mathbf{x}'_j$ includes the grade-level (kindergarten to fifth), gender (male and female), income-eligibility (free, reduced, and paid status) and race (white, black, Hispanic, and other) of the student purchasing the j^{th} entrée. Let grade-level act as a proxy for age and income-status as a proxy for family income. Lastly, a vector of dummy variables, $School'_j$, indicating which elementary school the j^{th} entrée is purchased, is included. There are eleven elementary schools; we maintain confidentiality by labeling each school 1 through 11.

Data

Data were collected from a suburban district in South Carolina with approximately 12,500 students in pre-kindergarten to twelfth grade. Student-level daily point of sale (POS) data were obtained from the Food and Nutrition Services Department cafeteria transaction logs for the period Jan 7, 2013 to April 30, 2013. The data were collected after implementation of the new USDA nutritional guidelines. In the cafeteria, students complete transactions by entering their unique personal identification number (PIN). The PIN is linked to account information regarding lunch price status and available funds; parents or students may add money to accounts at any time of the year. We utilized the PIN to track student-level purchases over the study period and to match transaction data to demographic data.

For students purchasing a NSLP qualifying lunch, the cashier enters “Entrée 1”, “Entrée 2”, or “Vegetarian Entrée” and the student’s account is debited the appropriate amount given the student’s income-eligibility status (Free, Reduced, or Paid).[22] The entrée numbers coincide with the order in which the entrées are listed on the monthly menus. The three daily entrees come with a choice of sides; this information is not entered into the POS database. Students may also have the opportunity to purchase a la carte foods, such as dessert, milk, or chips. These purchases are also recorded. However, the POS data on these purchases is not as clearly defined: the cashier may ring up a cookie as “Dessert” or use another button with an equivalent price. Furthermore, the manner in which these transactions are recorded is not yet standardized at the district-level. We limit the sample to elementary schools because they offer fewer a la carte options (food choices that are available for purchase outside of a qualifying NSLP lunch) than middle or high schools and a larger percent of K-5 students typically participate in the NSLP than middle or high school students (Fox & Condon 2012). In the sampled elementary schools, a la carte transactions account for less than 0.5 percent of total transactions. Given the available data, this paper focuses only on entrée purchases.

POS data were collected for each school day between January and April 2013 at the district’s eleven elementary schools. The district also provided all enrolled students’ race, gender, and grade level information. Thus, the dataset includes the race, gender, and

[22] If parents have a change in income at anytime during the school year, they can apply for a change in eligibility. This occurred for 174 students between January and April. In these cases, the lowest income level is used. For example, if a student’s status changes from “paid” to “reduced,” the student is considered reduced-price lunch status for the entire school year.

grade level of all students (including those students that do not have POS data because they have not purchased a NSLP lunch or a la carte item) and POS and income eligibility status data on students that have purchased a NSLP lunch at least once. If a student does not purchase a lunch on a particular day, we assume the child has brought a lunch from home.

Menu offerings are set at the district-level. During the period of investigation, there were 37 different entrée options offered in rotation. Most entrees provide the meat/meat alternative as well as a bread or grain (starch). Five entrees do not include a starch. Nutrition information for each of the entrées served (provided by the school district nutrition services director) includes total calories (kCal), fat (grams), sodium (milligrams), protein (grams), and carbohydrates (grams) per entrée. In some cases, the district uses more than one vendor for the same entrée option and it is therefore difficult to determine the nutritional information of a specific food item served on a particular day at a particular elementary school from the nutritional information provided by the district. For food items supplied by multiple vendors, we calculated the median nutritional values of each food item and used that value to estimate the calories and nutrients in the entrees offered. Once a month, a “Manager’s Choice” entrée is served. On these days, the cafeteria managers of each elementary school select the menu and therefore the offerings vary across elementary schools. These days are discarded because nutrition content information could not be calculated for this option without access to each cafeteria’s daily production records.

Results

Descriptive Statistics

The spring 2013 semester began on January 7 and POS data were collected through April 30. In the 66 school days represented in the dataset, 5,592 students purchased 279,698 school lunches. An additional 187 elementary students never purchased lunch. Table 4.1 provides summary statistics for the key demographics. Students are evenly distributed across kindergarten through fifth grades. The majority of elementary aged students are white, 33 percent are black, and 6 percent are Hispanic. Fifty-six percent of students receive lunch for free and 36 percent of students pay full price for school lunch. Only three percent of elementary school students did not receive a NSLP lunch at least once during the sample period. These students will be referred to as “Non-Participants” and should not be confused with students receiving a free NSLP lunch.

On average, a participating student purchased 50 school lunches in the 66-day sample period. Histograms in Figure 2.1 show that the distribution of lunches purchased differs depending on lunch-price status, with the average free-lunch student purchasing 13 more lunches (about 1 more per week) than the paid-lunch students. The five most purchased entrees are the “Vegetarian Tray” (12.5 percent of sales), “Chicken Sandwich on Whole Grain Bun” (10.6 percent) “Chicken Nuggets with Dipping Sauce” (9.0 percent) “Cheese Pizza on a Whole Grain Crust” (7.4 percent), and “Hamburger on Whole Grain Bun” (6.6 percent). However, these entrées are also offered more often than others, i.e. the “Vegetarian Tray” consists of a yogurt, cheese, and crackers and is available every day.

Given the number of days it is offered, the daily vegetarian option is actually one of the least popular entrees, averaging 528 transactions per day.

Using the average number of purchases per day for the days that the item was offered, the most popular entrée is "Chicken Nuggets with Dipping Sauce" (3,144 entrees purchased per day offered). Moreover, if all breaded bite-size chicken-style entrée transactions are combined (including chicken nuggets, chicken chunks, and popcorn chicken; served with or without a whole grain roll), bite-size chicken is served 13 days (19 percent of days sampled) with an average of 4,178 purchases per day. A nationally representative 2004-2005 study assessing school nutrition found 17 percent of daily menus offered some type of breaded/fried chicken product, so this district may offer this type of entrée slightly more than other school districts (Gordon et al. 2007a). Similarly, if all pizza-style entrée transactions are combined (including cheese pizza, pepperoni pizza, pizzatas, and stuffed crust dippers[23]), pizza-style entrees are served more than 30 percent of all days sampled, but only an average of 2,375 entrees are purchased per day when offered. The least popular entrees, measured by both percent of total sales and purchases per day offered are "Enchilada Pie with Whole Grain Roll" (0.12 percent of sales, 169 entrees purchased per day offered) and "Fish Nuggets with Dipping Sauce" (0.24 percent, 338 entrees per day).

Table 4.3 provides the nutritional values for the five most purchased entrees and Appendix G contains nutritional values and popularity ranking for all entrée options

[23] Stuffed crust dippers are mozzarella cheese wrapped in pizza crust (Rich's Food Service 2011a) and served with marinara sauce. Pizzatas are mozzarella cheese, pepperoni, and marinara sauce wrapped in pizza crust (Rich's Food Service 2011b).

offered during the sample period. On average, an entrée contains 340 calories, 15g fat, 783mg sodium, 32g protein, and 19g carbohydrates. There are no federal mandates regarding the nutrition of an NSLP entrée, so without the nutritional information of the other food components offered, we are unable to determine whether or not the average lunch meets the guidelines. However, the guidelines do require that a NSLP lunch provide between 550 and 650 calories (averaged over the week), leaving little wiggle room for very energy dense entrees. Figure 4.2 illustrates the distribution of the total nutrients per entrée. More than half of the 37 entrees have between 233 and 320kcal. The entrée highest in calories is "Chicken Alfredo with a Whole Grain Bun" (579 calories) and was only served once in our sample period. The entrée lowest in calories is "Deli Sliced Turkey on a Whole Grain Bun" (146.5 calories) and was only served twice. "Deli Sliced Turkey on a Whole Grain Bun" is also the entrée lowest in fat (2.2 grams). The "Rib-B-Q on a Whole Grain Bun" has the highest amount of fat (25.5 grams). Average total sodium is greater than the 640mg cap effective 2014/15, and more than half the entrees have sodium levels greater than 640mg. Total sodium ranges from 345mg in "Italian Spaghetti" to 1,301mg in "Grilled Cheese with Chicken Noodle Soup."

According to the 2004-2005 School Nutrition Dietary Assessment (SNDA-III), entrees can contribute as much as 61 percent of the total protein in an NSLP elementary school lunch (Gordon et al. 2007).[24] "Grilled Cheese" offers the least protein and "Chicken Alfredo with a Whole Grain Bun" offers the most protein. In this case, the entrée with the

[24] SNDA-III categorizes food groups differently than this paper. Our "Entrée" includes the following SNDA-III major food groups: combination entrees, meat/meat Alternatives, and bread/grains.

most protein is also the entrée with the highest calories. When transactions are separated by lunch-price status, the average nutritional values remain similar. However, there are a few statistically significant but numerically small differences. For example, paid-status lunches have 0.04 fewer grams of fat than free-status lunches on average (see Table 4.2).

Conditional Logit Results

Table 4.4 provides odds-ratios for three conditional logit models. Odds-ratios can be interpreted as the proportional change in the odds of student *i* selecting entree *j* for a unit increase in the variable of interest, holding all other variables constant. All standard errors are clustered at PIN level.

Model 1

When limiting the sample to students purchasing lunch at school, increasing the calorie content of a specific entrée by one kilocalorie decreases the likelihood of a student selecting that entrée by a small but statistically significant amount. Contrarily, a one-gram increase in the fat content of a specific entrée increases the likelihood of a student selecting that entrée. Positive and significant odds-ratios are also found for sodium and protein. The small magnitude of these results is not surprising, given the minute difference between, for example, a meal with 330kcal and one with 331kcal.

Model 2

Expanding the choice set to include lunch from home as a fourth alternative increases the number of observations by 362,604 to account for 90,651 observations in which students are assumed to bring a lunch from instead of one of the three entrees served at school.[25] Including these additional students does not change the signs or the magnitudes of the odds-ratios. The coefficient of the indicator variable *Home* is statistically significant. Assuming all lunches from home have the nutritionals of an average school entree, students are 16 percent less likely to choose that alternative instead of purchasing a lunch at school.

Model 3

The final model includes interactions between income-eligibility status and *Calories*, *Fat*, *Sodium*, *Protein*, and *Carbohydrates*. *Free lunch* status acts as the base category and thus the odds-ratios of the nutritionals without interactions represent the effect on the probability of choosing entrée *j* for students purchasing a free lunch. We find that income-eligibility does impact the probability of selecting a specific entrée. Relative to students receiving a free lunch, an increase in *Fat* and *Carbohydrates* decrease the likelihood of a paid-price lunch student selecting that entrée by a statistically significant amount. Relative to students receiving a free lunch, increases in *Protein* increase the likelihood of a paid-price lunch student selecting that entrée. No statistically significant differences across income were found for sodium. Lastly, an increase in *Calories* decreases the likelihood of a reduced-price lunch student selected that entrée relative to free-lunch students. For *Fat*, *Sodium*, *Protein*, and *Carbohydrates*, no statistically

[25] 362,604 additional observations/4 choices per student = 90,651 additional students.

significant differences between reduced-price and free-lunch students are found, suggesting these students respond similarly to changes in entrée nutritionals.

OLS Regression Results

It is important to remember that the data provide information on the entrée choice a student makes and the corresponding nutritional values. Recall that the dependent variables, Y_i, do not measure the nutrients *consumed*, only the nutrients *purchased*. For example, a positive coefficient on *Gender* would suggest that boys are systematically choosing entrees that are more energy dense (when Y_i = *Calories*) than girls. We would not know if boys are simultaneously choosing side items with fewer calories, or if girls are choosing more energy dense entrees and do not eat it all.

Calories

Race, Status, and *Gender* are not statistically significant (Table 4.5). *Grade,* our proxy for age, is significant. Relative to kindergartners, students in second to fifth grade choose entrees with more calories. Joint F-tests for *Status* and *Race* fail to reject the null hypothesis: neither income-eligibility status nor race influence the caloric content of a student's choice of entrée (Table 4.6).

Fat

The results for estimates pertaining to *Fat* are similar to the results pertaining to *Calories.* Black students purchase entrees with more fat than white students, but the resulting difference is negligible. The hypothesis that there is no significant difference across all

Race groups is rejected in favor of the alternative; similar results are found with *Grade.* Like the *Calories* model, the R^2 is very small: less than one-hundredth of a percent of variation in *Fat* can be explained by the explanatory variables. The coefficient for income-ineligible students (*Paid Status)* is significant and positive, suggesting that students purchasing a paid-lunch choose entrees with more fat than students purchasing free lunch. The joint F tests conclude that all four groups of explanatory variables contribute to the total fat grams a student selects.

Sodium

Compared to white students, black students all choose higher sodium entrees than white students. Students receiving free lunch (*Free Status*) choose entrees with less salt than students purchasing full-price lunches. The coefficient on *Gender* was also statistically significant: male students chose lower sodium entrees than female students.

As in the model where *Fat* is the dependent variable, as students get older, they choose entrees with greater amounts of sodium. Second graders choose entrees with 24.41mg more than kindergartners while fifth graders choose entrees with 45.9mg more sodium than kindergartners. The joint F tests conclude that all four groups of explanatory variables contribute to the total sodium a student is served.

Protein

When controlling for income, gender, age, and race, black students choose entrees with 0.24 more grams of protein than white students (the amount of protein in three baby carrots (U.S. Department of Agriculture 2011b)). The coefficients for *Other Race* and *Gender* are also statistically significant, but very small in magnitude (0.06 and 0.07g, respectively). Income-ineligible students choose entrees with 0.11g more protein than income-eligible students purchasing a free lunch. Similarly to the model for sodium, older students choose entrees with statistically larger amounts of protein.

Carbohydrates

In the final nutrient analysis, the joint F-tests suggest that Race, Status, Gender, Grade, and school contribute to the total carbohydrates a student is served. The coefficient for *Black* (compared to *White*) is negative and statistically significant but small in magnitude. We also find male students choose entrees with 0.14 fewer carbohydrates than female students. Additionally, younger students prefer entrees with more carbohydrates than older students.

Conclusion

In this study, we investigate the relationship between income-eligibility status (Free, Reduced, or Paid) and entrée selection. Using a unique dataset tracking daily entrée choices and their nutritional value among elementary students at a suburban school district, this paper provides a novel approach to understanding the healthfulness of the NSLP. Without controlling for age, gender, or race, OLS regression results conclude there is no difference in the caloric content of entrees selected by students purchasing free, reduced-price, or paid lunches. Conversely, students purchasing paid-lunches choose entrees with less fat and sodium than students purchasing free lunches. When controlling for age, gender, and race, students that receive a free lunch choose entrees with less sodium than students purchasing either reduced-price or paid lunches. Relative to students receiving free lunches, students purchasing paid lunches also choose entrees with more protein and fat.

Results from the conditional logit models conclude that while all students are more likely to select entrees with more fat, sodium, and protein, students purchasing free lunches are more likely than students purchasing paid-price lunches to select entrees with more fat and carbohydrates. In addition, students purchasing free lunch are less likely to select entrees with more protein than students purchasing paid-price lunches. While the new NSLP guidelines aim to reduce the fat and sodium content of all school lunches offered, students prefer these qualities in their foods. Implementing a school-wide nutritional education curriculum may improve the nutritional content actually consumed.

The data are collected five months after implementation of new guidelines. Although we do not collect data prior to implementation, it is likely that guidelines requiring each qualifying lunch to have an average of 550 to 650 calories led to the narrow distribution of calories among the 37 entrees offered at the elementary schools. The new guidelines also require sodium levels to be less than 650mg per meal, but this will not be effective until the 2014/15 school year. Future research may compare the distribution of sodium among entrees before and after the guideline come into effect. Lastly, POS data is limited to analysis of purchases, not consumption. The data do not allow the researchers to see if differences in entrée selections result in differences in entrée consumption patterns across income. Future research could examine the relationship between consumption and income status using plate waste data.

Table 4.1. Student Demographics

	All Students	Status: Free	Reduced	Paid	Non-Participant
Gender (Percent)					
Female	48.6	48.1	50.0	49.3	47.6
Male	51.4	52.0	50.0	50.7	52.4
Race (Percent)					
White	55.1	36.0	53.5	82.6	87.2
Black	32.5	47.8	31.9	10.9	5.3
Hispanic	5.7	8.5	5.0	1.7	1.6
Other	6.7	1.5	9.6	4.8	5.9
Grade (Percent)					
Kindergarten	17.4	19.2	16.3	15.4	11.2
First	18.3	18.7	17.0	17.7	18.7
Second	16.2	16.9	14.2	15.9	10.7
Third	16.1	15.3	16.3	17.5	13.9
Fourth	15.5	14.5	17.0	16.7	16.6
Fifth	16.5	15.4	19.2	16.8	28.9
Status (Percent)					
Free	56.3	100.0	0	0	0
Reduced	4.9	0	100.0	0	0
Paid	35.6	0	0	100.0	0
Non-Buyer	3.2	0	0	0	100.0
No. Meals Purchased	50.0	55.0	53.3	41.7	0
	(15.9)	(10.0)	(12.2)	(20.0)	
Total Students	5,779	3,252	282	2,058	187

Notes: "Other" includes students of Asian, Indian, Pacific Islander, or mixed race. Standard deviation listed in parentheses.

Table 4.2. Food Energy and Nutrients

	All Transactions			Mean By Status		
Food Energy	Mean	Min	Max	*Free*	*Reduced*	*Paid*
Calories (kCal)	334.47	146.50	579.00	334.56	333.90	334.38
	(50.54)			(50.74)	(50.60)	(50.13)
Nutrients						
Fat (g)	15.37	2.25	25.50	15.38	15.41	15.34*
	(4.75)			(4.77)	(4.77)	(4.71)
Sodium (mg)	722.30	345.00	1,301.00	721.80	727.11***	722.52††
	(242.24)			(242.03)	(240.39)	(242.99)
Protein (g)	18.52	11.00	34.50	18.50	18.51	18.55***
	(3.83)			(3.82)	(3.82)	(3.84)
Carbohydrates (g)	29.93	17.50	59.00	29.94	29.84*	29.91
	(7.33)			(7.35)	(7.29)	(7.31)
Total Transactions		279,698		178,865	15,023	85,810

Notes: Standard deviation listed in parentheses. Means statistically different than Free Status at the .1, .05, and .01 level denoted with *, **, and *** respectively. Differences between Reduced and Paid Status are denoted with †, ††, and †††.

Table 4.3. Nutritional Value of Top 5 Purchased Entrees

	Percent Sales	*Cal (kCal)*	*Fat (g)*	*Sodium (mg)*	*Protein (g)*	*Carbs (g)*
Entree						
Vegetarian Tray	12.46	325.0	12.5	395.0	14.0	37.5
Chicken Sandwich	10.58	316.5	11.5	727.5	19.5	36.0
Chicken Nuggets	8.99	326.0	12.0	656.0	15.0	19.0
Cheese Pizza	7.35	310.0	12.0	490.0	21.0	31.0
Hamburger	6.57	291.5	12.0	509.5	22.5	23.0

Notes: Vegetarian Tray is served each day and includes yogurt, cheese, and cracker. Chicken Nuggets are served with honey mustard dipping sauce. Chicken Sandwich is served on a whole grain bun. Hamburger served on a whole grain bun.

Table 4.4. Conditional Logit Results

	Exclude Lunch from Home	Include Lunch from Home	
	(1)	(2)	(3)
Choose Lunch From Home	-	0.842*** (0.015)	0.842*** (0.015)
Calories	0.998*** (0.0001)	0.999*** (0.0001)	0.999*** (0.0001)
Fat	1.058*** (0.002)	1.054*** (0.001)	1.055*** (0.002)
Sodium	1.0002*** (0.00002)	1.0003*** (0.00001)	1.0003*** (0.00002)
Protein	1.063*** (0.001)	1.056*** (0.001)	1.054*** (0.001)
Carbohydrates	0.964*** (0.0009)	0.958*** (0.0007)	0.959*** (0.001)
Calories x Status			
Reduced-Price x Calories	-	-	0.999* (0.0005)
Paid-Price x Calories	-	-	1.0001 (0.0002)
Fat x Status			
Reduced-Price x Fat	-	-	1.008 (0.005)
Paid-Price x Fat	-	-	0.995* (0.002)
Sodium x Status			
Reduced-Price x Sodium	-	-	1.00009 (0.00007)
Paid-Price x Sodium	-	-	.9999 (0.00003)
Protein x Status			
Reduced-Price x Protein	-	-	1.002 (0.004)
Paid-Price x Protein	-	-	1.004* (0.002)

continued…

Table 4.4 (continued). Conditional Logit Results

	Exclude Lunch from Home	Include Lunch from Home	
	(1)	**(2)**	**(3)**
Carbohydrates x Status			
Reduced-Price x Carbohydrates	-	-	1.001
			(0.003)
Paid-Price x Carbohydrates	-	-	0.998*
			(0.001)
Number of Observations	1,113,684	1,476,288	1,476,288
Log-Likelihood	-362,255	-477,529	-477,505

Notes: Odd-ratios are presented. Robust standard errors (in parentheses) are clustered at PIN level. *, **, *** indicate significance at α = 10%, 5% and 1%, respectively.

Table 4.5. OLS Regression Results

	(1) Calories (kCal)	(2) Fat (g)	(3) Sodium (mg)	(4) Protein (g)	(5) Carbs (g)
Race (White Omitted)					
Black	0.22	0.07**	15.47***	0.24***	-0.30***
	(0.23)	(0.03)	(2.14)	(0.03)	(0.05)
Hispanic	-0.20	-0.01	-3.01	0.02	0.02
	(0.39)	(0.05)	(3.89)	(0.06)	(0.09)
Other	-0.31	-0.06	5.59	0.06	-0.02
	(0.37)	(0.04)	(3.43)	(0.05)	(0.08)
Status (Free Omitted)					
Reduced	-0.41	0.05	6.81	0.03	-0.12
	(0.40)	(0.05)	(3.63)	(0.05)	(0.08)
Paid	0.40	0.07*	7.58***	0.11***	-0.10
	(0.24)	(0.03)	(2.21)	(0.03)	(0.05)
Gender (Female Omitted)					
Male	-0.17	-0.02	-3.44*	0.07**	-0.14***
	(0.18)	(0.02)	(1.65)	(0.02)	(0.04)
Grade (Kindergarten Omitted)					
First	-0.44	0.21***	5.62	-0.03	-0.39***
	(0.30)	(0.04)	(3.15)	(0.05)	(0.07)
Second	0.72*	0.34***	24.41***	0.15***	-0.59***
	(0.31)	(0.04)	(3.21)	(0.05)	(0.07)
Third	0.78*	0.36***	34.23***	0.30***	-0.71***
	(0.32)	(0.04)	(3.17)	(0.05)	(0.07)
Fourth	0.94**	0.36***	39.47***	0.43***	-0.85***
	(0.33)	(0.04)	(3.16)	(0.05)	(0.07)
Fifth	1.09***	0.45***	45.88***	0.47***	-0.94***
	(0.32)	(0.04)	(3.10)	(0.04)	(0.07)
School (School 11 Omitted)					
School 1	4.47***	0.46***	35.34***	0.45***	-0.40***
	(0.44)	(0.05)	(3.79)	(0.06)	(0.09)
School 2	3.31***	0.25***	17.48***	0.18**	0.13
	(0.42)	(0.05)	(3.81)	(0.06)	(0.09)

continued…

Table 4.5 (continued). OLS Regression Results

	(1) Calories (kCal)	(2) Fat (g)	(3) Sodium (mg)	(4) Protein (g)	(5) Carbs (g)
School (continued)					
School 3	2.69***	0.08	12.95***	0.22***	-0.04
	(0.41)	(0.05)	(3.90)	(0.06)	(0.09)
School 4	4.05***	0.30***	16.88***	0.20**	0.07
	(0.46)	(0.05)	(4.38)	(0.06)	(0.10)
School 5	1.02*	-0.03	12.80***	0.32***	-0.09
	(0.40)	(0.05)	(3.81)	(0.06)	(0.09)
School 6	0.65	-0.35***	13.56***	0.76***	-0.33***
	(0.42)	(0.05)	(3.57)	(0.05)	(0.09)
School 7	4.18***	-0.06	29.26***	0.80***	0.01
	(0.43)	(0.05)	(3.59)	(0.05)	(0.08)
School 8	2.85***	0.01	15.74***	0.41***	0.14
	(0.45)	(0.05)	(4.09)	(0.06)	(0.10)
School 9	0.07	-0.00	4.37	-0.18*	0.09
	(0.55)	(0.07)	(5.97)	(0.08)	(0.14)
School 10	1.40**	0.31***	29.90***	0.36***	-0.68***
	(0.47)	(0.05)	(4.17)	(0.06)	(0.10)
Constant	331.57***	14.96***	673.71***	17.79***	30.82***
	(0.41)	(0.05)	(4.15)	(0.06)	(0.09)
R^- Squared	0.0010	0.0032	0.0084	0.0089	0.0039
F-Test	15.28	33.11	33.14	44.08	24.73
p-value	0.0000	0.0000	0.0000	0.0000	0.0000

Notes: "Other" includes students of Asian, Indian, Pacific Islander, or mixed race. Robust standard errors (in parentheses) are clustered at PIN level. *, **, *** indicate significance at α = 10%, 5% and 1%, respectively. Number of observations for each regression is 279,698.

Table 4.6. Joint F Tests for Indicator Variables

	(1) Calories	(2) Fat	(3) Sodium	(4) Protein	(5) Carbs
Race					
F Test	0.94	4.59	21.53	21.48	14.71
p-value	0.4182	0.0000	0.0000	0.0000	0.0000
Status					
F Test	2.29	3.29	6.47	5.52	2.23
p-value	0.1013	0.0372	0.0000	0.0000	0.1072
Grade					
F Test	6.84	35.29	74.37	46.71	42.24
p-value	0.0000	0.0000	0.0000	0.0000	0.0000
School					
F Test	26.99	44.08	14.07	53.22	15.39
p-value	0.0000	0.0000	0.0000	0.0000	0.0000

Note: F jointly tests the hypothesis that coefficients for each indicator variable (Race, Status, Grade, School) are different than zero.

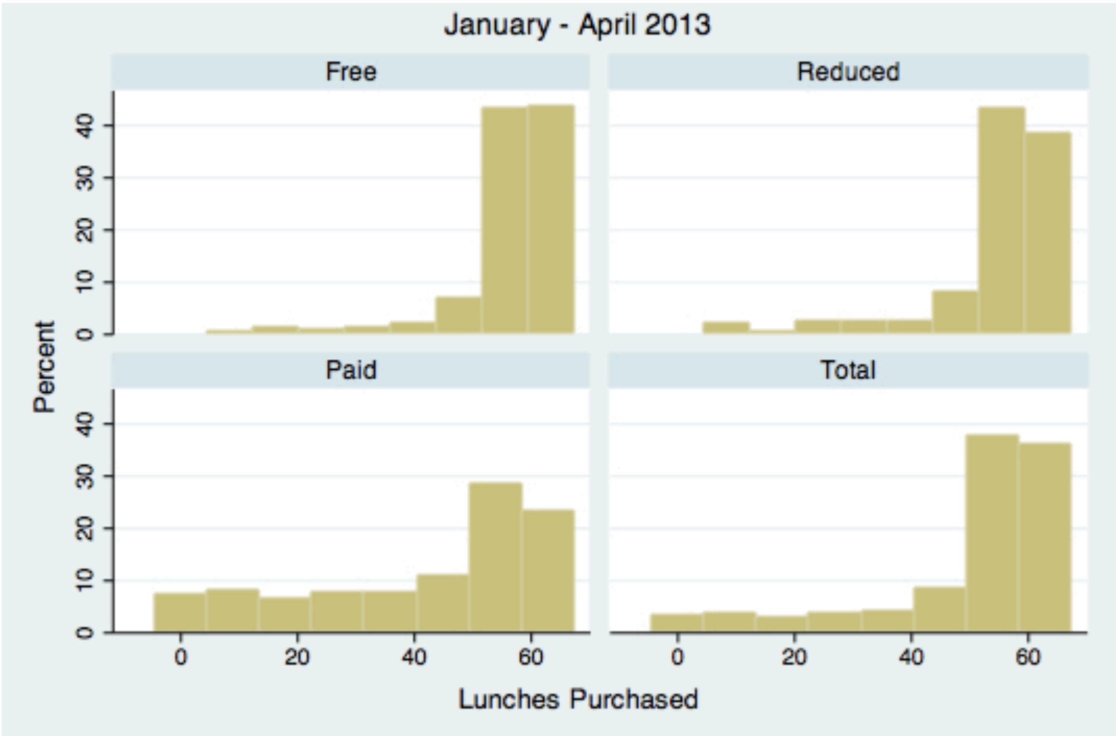

Figure 4.1. Total Number of Lunches Purchased per Student

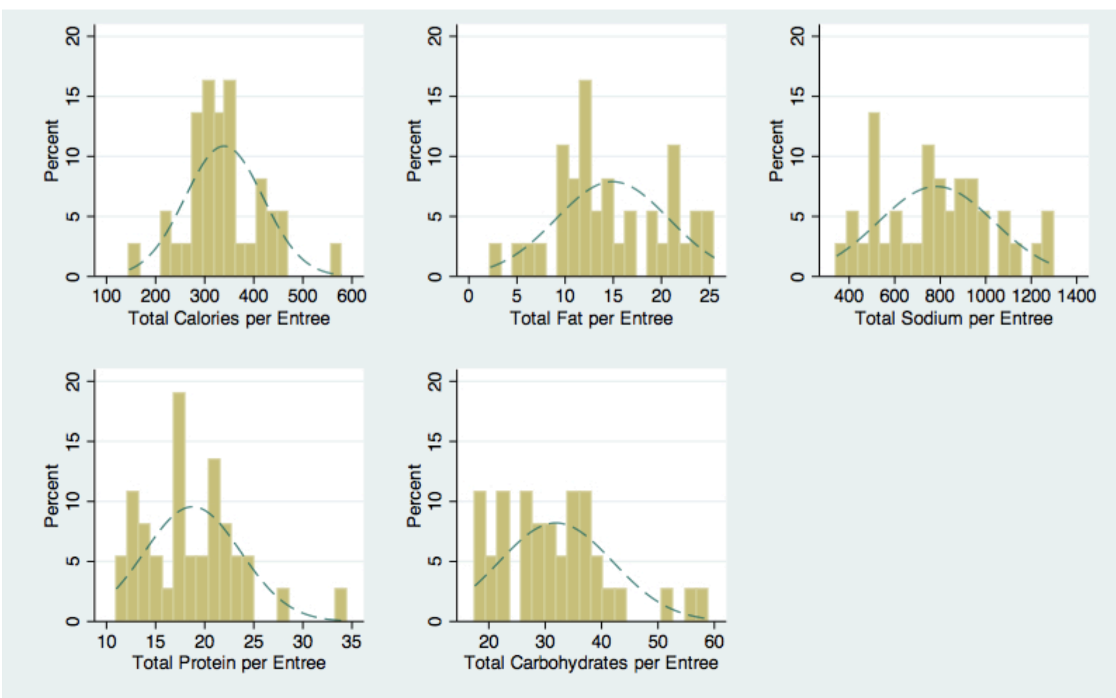

Figure 4.2. Food Energy and Nutrients by Entree

APPENDICES

Appendix A. National School Lunch Program Weekly Meal Pattern

Table A.1. Weekly Meal Pattern for Kindergarten to Fifth Grade

	Required Amount	
	Weekly	Daily
Fruits (cups)	2.5	0.5
Vegetables (cups)	3.75	0.75
Dark Green[a]	0.5	-
Red/Orange[b]	0.75	-
Legumes[c]	0.5	-
Starchy[d]	0.5	-
Other[e]	0.5	-
Additional Veg. to Reach Total	1	-
Grain/Bread (oz eq)	8 to 9	1
Meat/Meat Alternatives (oz eq)	8 to 10	1
Milk (cups)	5	1
Calories (kcal)		Must average 550 to 650
Saturated Fat (% kcal from sat. fat)		≤ 10
Sodium (mg)		Must average ≤ 640

Notes: [a] Dark green vegetables include bok choy, broccoli, collards, dark green leafy lettuce, kale, mesclun, mustard greens, romaine, spinach, and turnip. [b] Red/orange vegetables include acorn squash, butternut squash, carrots, pumpkin, tomatoes, and sweet potatoes. [c] Legumes include black beans, dry black-eyed peas, chick-peas, kidney, lentil, navy beans, soy beans, split peas, and white beans. [d] Starchy vegetables include non-dry black eyed peas, corn, cassava, green banana, green peas, green lima beans, plantains, taro, water chestnut, white potatoes. [e] Other vegetables include all other fresh, frozen, canned veggies cooked or raw, such as artichokes, asparagus, avocado, bean sprouts, beets, brussel sprouts, cabbage, cauliflower, celery, cucumber, eggplant, green beans, green peppers, iceberg lettuce, mushrooms, okra, onion, parsnips, turnips, wax beans, and zucchini. Requirements are for meals as offered for a 5-day school week. These represent minimum portion sizes. Milk can be flavored skim milk or unflavored 1% or skim milk. Beginning in SY 2012/13, 50 percent of all grains must be whole grain rich; effective SY 2014/15 all grains must be whole grain rich. Sodium requirement is effective beginning in SY 2014/15 (U.S. Department of Agriculture 2012).

Appendix B. State Policies

Table B.1. State Nutrition Policies By Region

	(1) 2+ Entrees Offered Daily	(2) 2+ Vegetables Offered Daily	(3) 2+ Fruits Offered Daily	(4) Food Service Coordinator Required	(5) Limit Access to Vending Machines
South					
Alabama	Rec	None	None	Yes	Require
Arkansas	Rec	None	None	Yes	Require
Florida	None	None	None	Yes	None
Georgia	Rec	Rec	Rec	Yes	Require
Kentucky	None	None	None	Yes	Require
Louisiana	Rec	Rec	None	No	Require
Maryland	None	None	None	No	Rec
Mississippi	Rec	None	Rec	Yes	None
Delaware	Rec	None	Rec	Yes	None
Dist. of Columbia	None	None	None	Yes	Require
North Carolina	Rec	Rec	Rec	No	Rec
Oklahoma	None	None	None	No	None
South Carolina	Require	Require	Rec	No	Rec
Tennessee	Rec	Rec	Rec	Yes	Require
Texas	Rec	None	None	No	None
Virginia	Rec	Rec	Rec	No	None
West Virginia	Rec	Rec	Rec	Yes	Require
West					
Alaska	None	None	None	No	None
Arizona	None	Require	Require	Yes	None
California	None	None	None	No	None
Colorado	None	None	None	No	Require
Hawaii	None	None	None	Yes	Rec
Idaho	Rec	Rec	Rec	No	None
Montana	Rec	Rec	Rec	No	None
Nevada	Rec	None	None	Yes	None
New Mexico	Require	Rec	Require	No	Require
Oregon	Rec	Rec	Rec	No	Rec
Utah	Rec	None	Rec	No	Rec

continued…

Table B.1 (continued). State Nutrition Policies By Region

	(1) 2+ Entrees Offered Daily	(2) 2+ Vegetables Offered Daily	(3) 2+ Fruits Offered Daily	(4) Food Service Coordinator Required	(5) Limit Access to Vending Machines
West (continued)					
Washington	None	None	None	No	Require
Wyoming	None	Rec	None	No	Rec
North					
Connecticut	Rec	Rec	Rec	No	Rec
Maine	None	None	None	No	None
Massachusetts	Rec	Rec	Rec	No	Rec
New Hampshire	None	None	None	No	None
New Jersey	None	None	None	No	Require
New York	Require	Rec	Rec	Yes	Require
Pennsylvania	Rec	Rec	Rec	No	None
Rhode Island	None	None	None	Yes	Require
Vermont	Rec	Rec	Rec	Yes	Require
Midwest					
Illinois	None	None	None	No	None
Indiana	None	None	None	No	None
Iowa	None	Rec	Rec	No	Rec
Kansas	Rec	Rec	Rec	Yes	Require
Michigan	None	None	None	No	Require
Minnesota	None	None	None	Yes	Require
Missouri	Rec	Rec	Rec	Yes	Rec
Nebraska	None	None	None	No	Rec
North Dakota	Rec	Rec	Rec	No	None
Ohio	Rec	None	None	No	None
South Dakota	Rec	None	None	No	None
Wisconsin	None	None	None	No	None

Notes: Recommended is abbreviated "Rec." A food service representative from each state was asked the following questions regarding health and nutrition policies. (1) Does the state require or recommend that schools offer students a choice between 2 or more different lunch entrées daily? (2) Does the state require or recommend that schools offer students a choice between 2 or more different vegetables daily? (3) Does the state require or recommend that schools offer students a choice between 2 or more different fruits daily? (4) Has your state adopted a policy stating that each district will have someone to oversee or coordinate food service in the district, such as a district food service director? (5) Does your state require or recommend that elementary schools prohibit student access to vending machines for at least part of the school day? (Center for Disease Control and Prevention 2007)

Appendix C. Results for Vegetable Subgroups

Table C.1. Model 1, Vegetable Subgroups

	Vegetable Subgroup				
	(1)	(2)	(3)	(4)	(5)
	Green	Red/Orange	Legumes	Starchy	Other
Income	0.691	-0.135	0.596	-0.442	-0.170
	(0.598)	(0.747)	(0.554)	(0.677)	(0.858)
$Income^2$	-0.111	0.029	-0.091	0.065	0.019
	(0.092)	(0.118)	(0.088)	(0.103)	(0.143)
$Income^3$	0.007	-0.001	0.005	-0.002	-0.000
	(0.005)	(0.006)	(0.005)	(0.005)	(0.008)
Attained BA	-0.742	-0.791	-1.252	-1.334	0.477
	(0.630)	(0.877)	(0.718)	(0.742)	(0.728)
Race (White Omitted)					
Black	0.665*	-0.741**	-0.256	-0.389	-0.218
	(0.266)	(0.273)	(0.159)	(0.266)	(0.291)
Hispanic	-0.129	0.009	-0.145	-0.525*	0.030
	(0.218)	(0.262)	(0.159)	(0.214)	(0.257)
Other	-0.726*	-0.201	-0.249	-1.460**	-1.219**
	(0.363)	(0.620)	(0.393)	(0.447)	(0.418)
Urbanicity (Urban Omitted)					
Suburban	0.102	0.135	-0.061	-0.094	0.168
	(0.120)	(0.150)	(0.093)	(0.111)	(0.117)
Rural	-0.044	-0.024	-0.063	0.212	0.302
	(0.146)	(0.181)	(0.140)	(0.158)	(0.166)
ln(Enrollment)	0.083*	0.146***	0.022	0.028	0.080
	(0.035)	(0.042)	(0.028)	(0.036)	(0.047)
Region (North Omitted)					
Midwest	0.270	0.100	0.039	0.409**	0.363*
	(0.150)	(0.176)	(0.113)	(0.147)	(0.155)
South	0.198	0.212	0.420**	0.662***	0.647**
	(0.171)	(0.231)	(0.140)	(0.169)	(0.234)
West	-0.189	-0.444*	-0.206*	-0.234	-0.101
	(0.154)	(0.192)	(0.101)	(0.145)	(0.176)

continued…

Table C.1 (continued). Model 1, Vegetable Subgroups

	Vegetable Subgroup				
	(1)	(2)	(3)	(4)	(5)
Vending	-0.009	-0.153	-0.125	-0.116	-0.211*
	(0.092)	(0.118)	(0.075)	(0.098)	(0.095)
Coordinator	0.042	-0.012	0.027	0.013	-0.180
	(0.126)	(0.173)	(0.123)	(0.129)	(0.159)
Vegetable Policy	0.134	0.093	0.090	0.174	0.065
	(0.085)	(0.107)	(0.073)	(0.098)	(0.090)
Month (Month1 Omitted)					
Month2	-0.116	-0.147	-0.206	0.001	-0.083
	(0.152)	(0.208)	(0.130)	(0.144)	(0.151)
Month3	-0.156	-0.208	-0.120	0.098	0.031
	(0.142)	(0.191)	(0.123)	(0.128)	(0.132)
Constant	-1.086	0.921	0.058	2.803*	0.589
	(1.241)	(1.572)	(1.117)	(1.395)	(1.639)
R^2	0.085	0.050	0.059	0.151	0.060

Notes: The number of observations for each regression is 816. Robust standard errors are in parentheses.
*, **, *** indicate significance at α = 10%, 5% and 1%, respectively.

Table C.2. Model 2, Vegetable Subgroups

	Vegetable Subgroup				
	(1)	(2)	(3)	(4)	(5)
	Green	Red/Orange	Legumes	Starchy	Other
LnIncome	0.621*	0.410	0.318	0.268	0.223
	(0.271)	(0.358)	(0.278)	(0.300)	(0.311)
Attained BA	-0.688	-0.753	-1.249	-1.279	0.515
	(0.628)	(0.871)	(0.723)	(0.742)	(0.719)
Race (White Omitted)					
Black	0.669*	-0.716**	-0.269	-0.346	-0.189
	(0.261)	(0.271)	(0.157)	(0.259)	(0.284)
Hispanic	-0.119	0.017	-0.144	-0.512*	0.041
	(0.216)	(0.261)	(0.159)	(0.212)	(0.254)
Other	-0.660	-0.122	-0.262	-1.325**	-1.114**
	(0.341)	(0.596)	(0.384)	(0.434)	(0.391)
Urbanicity (Urban Omitted)					
Suburban	0.117	0.148	-0.060	-0.074	0.185
	(0.119)	(0.148)	(0.094)	(0.111)	(0.116)
Rural	-0.033	-0.010	-0.066	0.235	0.320*
	(0.144)	(0.177)	(0.137)	(0.157)	(0.162)
ln(Enrollment)	0.082*	0.143***	0.023	0.021	0.075
	(0.035)	(0.042)	(0.028)	(0.036)	(0.046)
Region (North Omitted)					
Midwest	0.289	0.091	0.056	0.396**	0.360*
	(0.150)	(0.173)	(0.112)	(0.146)	(0.151)
South	0.242	0.226	0.436**	0.689***	0.678**
	(0.169)	(0.226)	(0.135)	(0.167)	(0.230)
West	-0.184	-0.453*	-0.197*	-0.249	-0.108
	(0.153)	(0.191)	(0.100)	(0.144)	(0.172)
Vending	-0.005	-0.152	-0.123	-0.113	-0.208*
	(0.093)	(0.117)	(0.075)	(0.098)	(0.095)
Coordinator	0.038	-0.013	0.025	0.011	-0.182
	(0.126)	(0.173)	(0.122)	(0.130)	(0.159)

continued…

Table C.2 (continued). Model 2, Vegetable Subgroups

	Vegetable Subgroup				
	(1) Green	(2) Red/Orange	(3) Legumes	(4) Starchy	(5) Other
Month (Month1 Omitted)					
Month2	-0.111	-0.143	-0.206	0.008	-0.078
	(0.152)	(0.207)	(0.130)	(0.144)	(0.151)
Month3	-0.148	-0.204	-0.118	0.105	0.037
	(0.142)	(0.191)	(0.123)	(0.128)	(0.132)
Vegetable Policy	0.148	0.096	0.097	0.180	0.073
	(0.084)	(0.105)	(0.072)	(0.098)	(0.089)
Constant	-6.320*	-3.578	-2.109	-0.928	-2.187
	(2.835)	(3.684)	(2.894)	(3.126)	(3.293)
R^2	0.081	0.050	0.058	0.149	0.058

Notes: The number of observations for each regression is 816. Robust standard errors are in parentheses. *, **, *** indicate significance at α = 10%, 5% and 1%, respectively.

Table C.3. Model 3, Vegetable Subgroups

	Vegetable Subgroup				
	(1) Green	(2) Red/Orange	(3) Legumes	(4) Starchy	(5) Other
Income Dummy (<=3.5 Omitted)					
Income > 3.5	0.070	-0.012	0.146	-0.049	0.028
	(0.154)	(0.209)	(0.102)	(0.205)	(0.162)
Income > 4.5	0.120	0.190	0.109	0.036	0.163
	(0.109)	(0.137)	(0.122)	(0.127)	(0.114)
Income > 5.5	0.001	-0.081	-0.221*	-0.151	-0.038
	(0.150)	(0.172)	(0.097)	(0.133)	(0.177)
Income > 6.5	0.090	0.095	0.213*	0.245	-0.022
	(0.160)	(0.211)	(0.105)	(0.157)	(0.204)
Attained BA	-0.164	-0.481	-0.875	-0.919	0.610
	(0.582)	(0.819)	(0.613)	(0.672)	(0.698)
Race (White Omitted)					
Black	0.634*	-0.729**	-0.242	-0.381	-0.176
	(0.270)	(0.279)	(0.157)	(0.268)	(0.281)
Hispanic	-0.121	-0.013	-0.155	-0.522*	0.017
	(0.222)	(0.263)	(0.167)	(0.219)	(0.254)
Other	-0.622	-0.098	-0.211	-1.412**	-1.037*
	(0.359)	(0.618)	(0.387)	(0.454)	(0.412)
Urbanicity (Urban Omitted)					
Suburban	0.145	0.164	-0.034	-0.060	0.196
	(0.117)	(0.148)	(0.090)	(0.109)	(0.116)
Rural	0.003	0.006	-0.025	0.254	0.329*
	(0.145)	(0.181)	(0.142)	(0.159)	(0.162)
ln(Enrollment)	0.088*	0.143***	0.023	0.028	0.072
	(0.035)	(0.042)	(0.028)	(0.036)	(0.046)
Region (North Omitted)					
Midwest	0.254	0.077	0.028	0.390**	0.347*
	(0.152)	(0.174)	(0.111)	(0.145)	(0.150)
South	0.221	0.241	0.434**	0.677***	0.698**
	(0.170)	(0.226)	(0.132)	(0.167)	(0.227)
West	-0.210	-0.456*	-0.205*	-0.247	-0.113
	(0.155)	(0.190)	(0.102)	(0.145)	(0.167)

continued…

Table C.3 (continued). Model 3, Vegetable Subgroups

	Vegetable Subgroup				
	(1) Green	(2) Red/Orange	(3) Legumes	(4) Starchy	(5) Other
Vending	-0.019	-0.155	-0.125	-0.116	-0.209*
	(0.094)	(0.118)	(0.075)	(0.098)	(0.095)
Coordinator	0.017	-0.032	0.011	-0.007	-0.191
	(0.127)	(0.173)	(0.121)	(0.129)	(0.161)
Month (Month1 Omitted)					
Month2	-0.103	-0.143	-0.209	0.007	-0.078
	(0.153)	(0.208)	(0.130)	(0.144)	(0.152)
Month3	-0.144	-0.204	-0.119	0.104	0.037
	(0.143)	(0.191)	(0.123)	(0.128)	(0.133)
Vegetable Policy	0.140	0.093	0.096	0.176	0.072
	(0.086)	(0.106)	(0.073)	(0.099)	(0.091)
Constant	0.051	0.676	1.038***	1.854***	0.107
	(0.399)	(0.531)	(0.300)	(0.416)	(0.449)
R^2	0.077	0.050	0.062	0.150	0.060

Notes: The number of observations for each regression is 816. Robust standard errors are in parentheses. *, **, *** indicate significance at α = 10%, 5% and 1%, respectively.

Table C.4. Model 4, Vegetable Subgroups

	Vegetable Subgroup				
	(1) Green	(2) Red/Orange	(3) Legumes	(4) Starchy	(5) Other
Eligible	-0.373	-0.901*	-0.303	0.216	0.291
	(0.271)	(0.350)	(0.179)	(0.269)	(0.266)
Attained BA	-0.006	-0.866	-0.997*	-0.660	1.127
	(0.506)	(0.687)	(0.444)	(0.547)	(0.630)
Race (White Omitted)					
Black	0.767**	-0.313	-0.162	-0.498	-0.373
	(0.292)	(0.329)	(0.181)	(0.293)	(0.302)
Hispanic	0.050	0.412	-0.009	-0.602*	-0.082
	(0.239)	(0.308)	(0.175)	(0.246)	(0.270)
Other	-0.580	0.000	-0.209	-1.330**	-1.130**
	(0.332)	(0.584)	(0.376)	(0.431)	(0.395)
Urbanicity (Urban Omitted)					
Suburban	0.133	0.105	-0.061	-0.036	0.225
	(0.118)	(0.147)	(0.093)	(0.110)	(0.117)
Rural	0.003	-0.030	-0.054	0.276	0.361*
	(0.146)	(0.177)	(0.148)	(0.159)	(0.159)
ln(Enrollment)	0.091*	0.137**	0.026	0.032	0.086
	(0.035)	(0.042)	(0.031)	(0.036)	(0.046)
Region (North Omitted)					
Midwest	0.244	0.100	0.039	0.354*	0.319*
	(0.147)	(0.172)	(0.103)	(0.140)	(0.147)
South	0.207	0.268	0.429**	0.636***	0.622**
	(0.167)	(0.228)	(0.143)	(0.168)	(0.219)
West	-0.223	-0.445*	-0.211*	-0.286*	-0.145
	(0.152)	(0.190)	(0.106)	(0.144)	(0.166)
Vending	-0.031	-0.163	-0.135	-0.128	-0.222*
	(0.093)	(0.117)	(0.078)	(0.098)	(0.094)
Coordinator	-0.002	-0.062	0.001	0.007	-0.181
	(0.128)	(0.174)	(0.123)	(0.130)	(0.162)

continued…

Table C.4 (continued). Model 4, Vegetable Subgroups

	Vegetable Subgroup				
	(1) Green	(2) Red/Orange	(3) Legumes	(4) Starchy	(5) Other
Month (Month1 Omitted)					
Month2	-0.108	-0.175	-0.211	0.029	-0.054
	(0.153)	(0.204)	(0.128)	(0.144)	(0.151)
Month3	-0.156	-0.235	-0.126	0.116	0.051
	(0.143)	(0.189)	(0.123)	(0.128)	(0.133)
Vegetable Policy	0.135	0.104	0.093	0.164	0.057
	(0.085)	(0.107)	(0.074)	(0.098)	(0.089)
Constant	0.300	1.267*	1.359***	1.655***	-0.111
	(0.450)	(0.545)	(0.320)	(0.412)	(0.475)
R^2	0.077	0.055	0.057	0.149	0.058

Notes: The number of observations for each regression is 816. Robust standard errors are in parentheses.
*, **, *** indicate significance at α = 10%, 5% and 1%, respectively.

Table C.5. Model 5, Vegetable Subgroups

	Vegetable Subgroup				
	(1) Green	(2) Red/Orange	(3) Legumes	(4) Starchy	(5) Other
Eligible Dummy					
(<= 0.20 Omitted)					
Eligible > 0.20	-0.023	0.036	-0.184	0.179	0.143
	(0.141)	(0.173)	(0.105)	(0.139)	(0.167)
Eligible > 0.40	-0.192	-0.221	0.000	-0.191	0.012
	(0.119)	(0.161)	(0.134)	(0.134)	(0.144)
Eligible > 0.60	0.066	-0.375*	-0.119	0.084	-0.026
	(0.123)	(0.154)	(0.103)	(0.137)	(0.127)
Eligible > 0.80	0.028	0.172	0.022	0.329	-0.054
	(0.172)	(0.182)	(0.107)	(0.185)	(0.177)
Attained BA	0.023	-0.851	-1.038*	-0.850	0.987
	(0.512)	(0.687)	(0.527)	(0.573)	(0.620)
Race (White Omitted)					
Black	0.614	-0.341	-0.141	-0.615*	-0.214
	(0.323)	(0.345)	(0.183)	(0.292)	(0.299)
Hispanic	-0.076	0.421	0.008	-0.689*	0.057
	(0.265)	(0.326)	(0.184)	(0.270)	(0.292)
Other	-0.634	0.070	-0.228	-1.362**	-1.049**
	(0.347)	(0.601)	(0.378)	(0.427)	(0.399)
Urbanicity (Urban Omitted)					
Suburban	0.133	0.083	-0.065	-0.066	0.209
	(0.119)	(0.147)	(0.098)	(0.112)	(0.116)
Rural	-0.012	-0.045	-0.043	0.227	0.343*
	(0.143)	(0.176)	(0.132)	(0.154)	(0.162)
ln(Enrollment)	0.098**	0.137**	0.027	0.040	0.077
	(0.035)	(0.042)	(0.030)	(0.037)	(0.045)
Region (North Omitted)					
Midwest	0.247	0.038	0.056	0.341*	0.304
	(0.146)	(0.171)	(0.103)	(0.140)	(0.155)
South	0.216	0.240	0.453**	0.657***	0.612**
	(0.167)	(0.228)	(0.144)	(0.168)	(0.225)
West	-0.210	-0.485*	-0.190	-0.278	-0.167
	(0.149)	(0.189)	(0.109)	(0.146)	(0.170)

continued…

Table C.5 (continued). Model 5, Vegetable Subgroups

	Vegetable Subgroup				
	(1) Green	(2) Red/Orange	(3) Legumes	(4) Starchy	(5) Other
Vending	-0.044	-0.184	-0.132	-0.149	-0.222*
	(0.093)	(0.117)	(0.081)	(0.100)	(0.097)
Coordinator	0.022	-0.047	-0.009	0.039	-0.188
	(0.127)	(0.171)	(0.119)	(0.129)	(0.160)
Month (Month1 Omitted)					
Month2	-0.092	-0.168	-0.219	0.043	-0.064
	(0.154)	(0.207)	(0.131)	(0.146)	(0.152)
Month3	-0.146	-0.241	-0.131	0.124	0.041
	(0.144)	(0.190)	(0.126)	(0.130)	(0.134)
Vegetable Policy	0.139	0.096	0.094	0.173	0.058
	(0.084)	(0.106)	(0.072)	(0.098)	(0.089)
Constant	0.212	1.099*	1.387***	1.702***	0.004
	(0.425)	(0.530)	(0.316)	(0.410)	(0.475)
R^2	0.079	0.059	0.060	0.155	0.059

Notes: The number of observations for each regression is 816. Robust standard errors are in parentheses.
*, **, *** indicate significance at α = 10%, 5% and 1%, respectively.

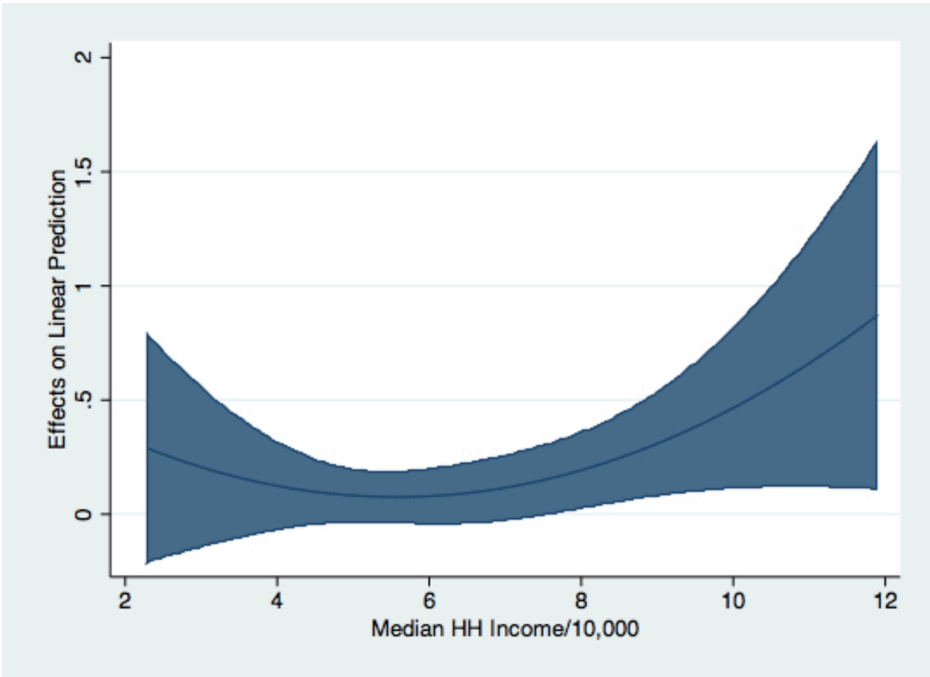

Figure C.1. Marginal Effects of Median County Income on Number of Dark Green Vegetables Offered Weekly

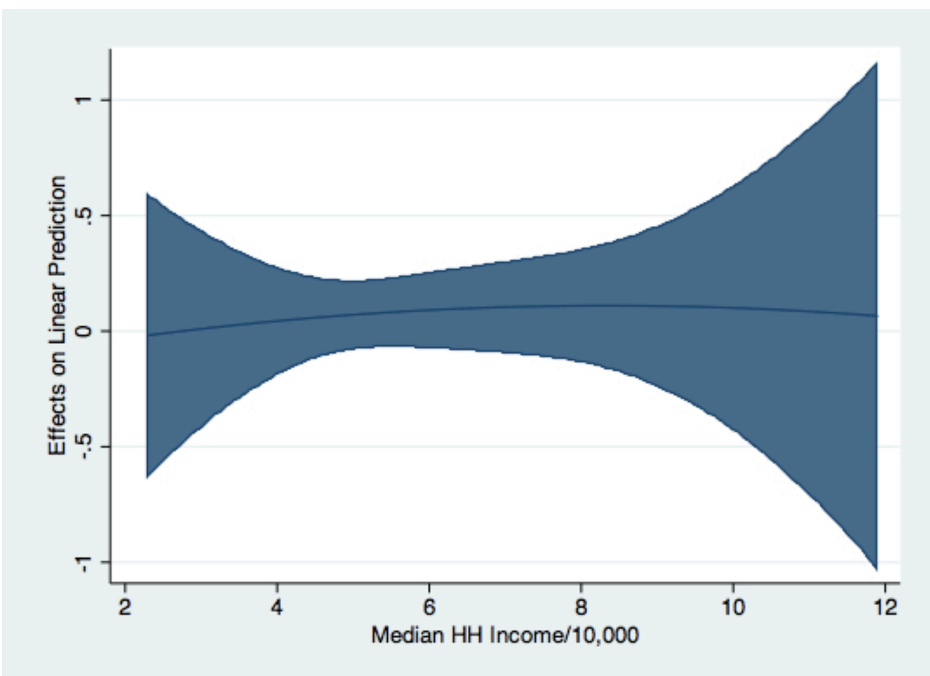

Figure C.2. Marginal Effects of Median County Income on Number of Red/Orange Vegetables Offered Weekly

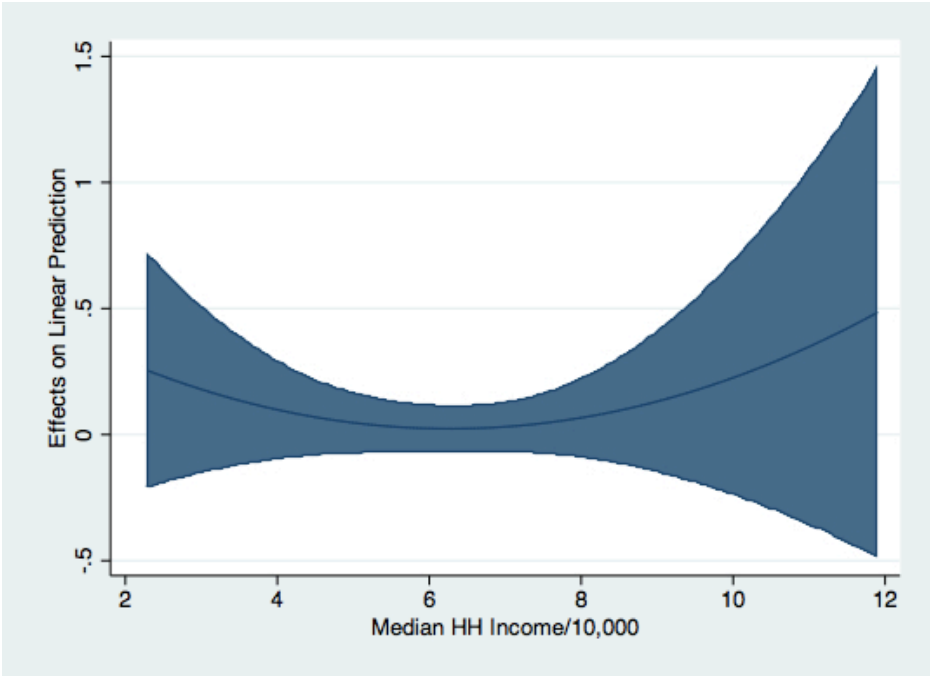

Figure C.3. Marginal Effects of Median County Income on Number of Legumes Offered Weekly

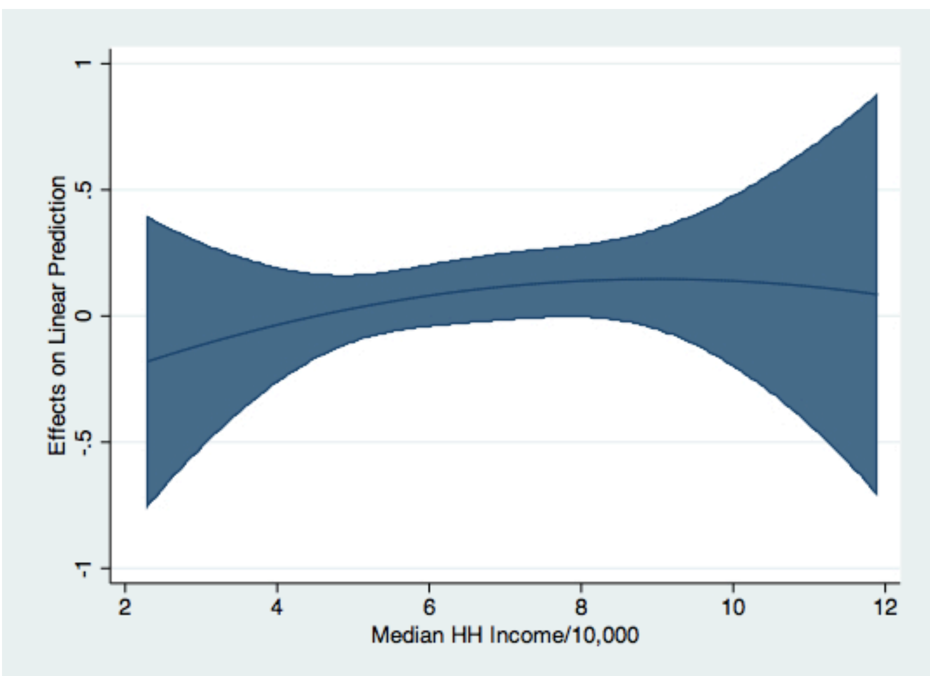

Figure C.4. Marginal Effects of Median County Income on Number of Starchy Vegetables Offered Weekly

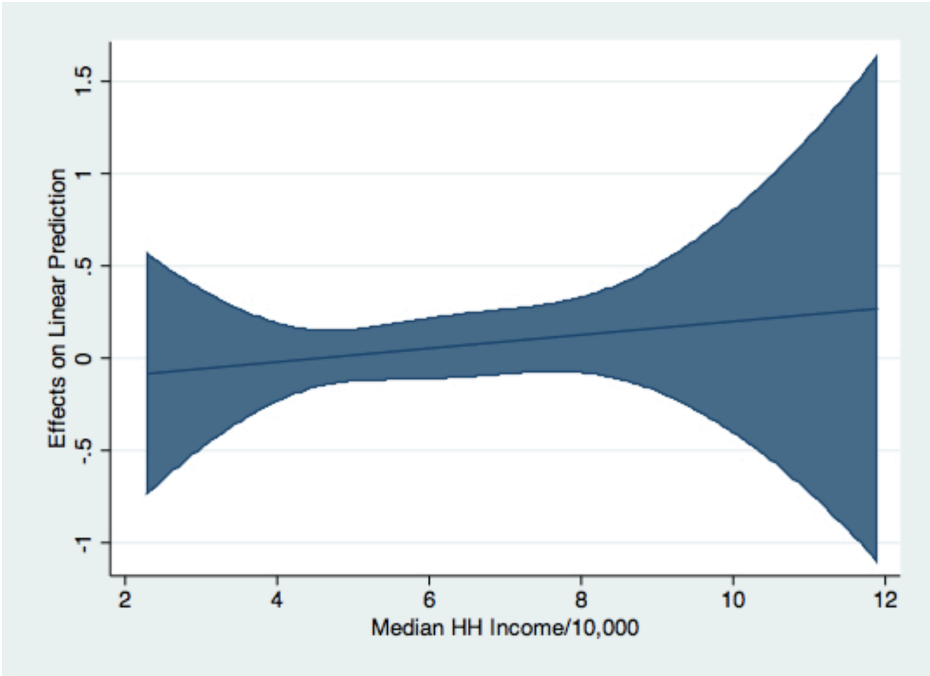

Figure C.5. Marginal Effects of Median County Income on Number of Other Vegetables Offered Weekly

Appendix D. Additional Income Specifications

Table D.1. Additional Income Specifications, Total Entrees and Total Fruit

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total Entrees				Total Fruit			
LnIncome	-107.588	-	-	-	2.705	-	-	-
	(66.906)				(36.909)			
$LnIncome^2$	5.181	-	-	-	-0.023	-	-	-
	(3.100)				(1.704)			
Income	-	0.999**	-0.861	-0.950	-	0.385	0.793	-2.811
		(0.308)	(1.142)	(11.091)		(0.196)	(0.665)	(6.869)
$Income^2$	-	-	0.154	0.772	-	-	-0.034	0.941
			(0.095)	(2.716)			(0.050)	(1.643)
$Income^3$	-	-	-	-0.127	-	-	-	-0.110
				(0.279)				(0.166)
$Income^4$	-	-	-	0.007	-	-	-	0.004
				(0.010)				(0.006)
Attained BA	2.235	1.705	2.396	2.075	-3.309	-3.137	-3.298	-3.365
	(3.561)	(3.564)	(3.559)	(3.574)	(2.432)	(2.386)	(2.436)	(2.442)
Race (White Omitted)								
Black	-2.508*	-2.264	-2.535*	-2.256	0.316	0.236	0.294	0.301
	(1.187)	(1.169)	(1.166)	(1.202)	(0.769)	(0.748)	(0.762)	(0.767)
Hispanic	-0.773	-0.720	-0.755	-0.737	-0.869	-0.890	-0.875	-0.894
	(1.440)	(1.434)	(1.436)	(1.453)	(0.703)	(0.701)	(0.702)	(0.706)
Other	-1.815	-1.408	-2.015	-1.472	-1.542	-1.713	-1.571	-1.533
	(2.592)	(2.499)	(2.572)	(2.543)	(1.388)	(1.355)	(1.388)	(1.379)

continued…

Table D.1 (continued). Additional Income Specifications, Total Entrees and Total Fruit

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total Entrees				Total Fruit			
Urbanicity (Urban Omitted)								
Suburban	0.328	0.364	0.301	0.326	0.872*	0.856*	0.870*	0.867*
	(0.625)	(0.620)	(0.623)	(0.625)	(0.420)	(0.420)	(0.421)	(0.421)
Rural	-0.959	-0.913	-0.971	-0.916	0.565	0.548	0.559	0.554
	(0.804)	(0.796)	(0.798)	(0.806)	(0.580)	(0.576)	(0.577)	(0.582)
ln(Enrollment)	1.121***	1.089***	1.130***	1.089***	0.546***	0.558***	0.549***	0.545***
	(0.186)	(0.184)	(0.186)	(0.185)	(0.124)	(0.123)	(0.124)	(0.124)
Region (North Omitted)								
Midwest	-4.407***	-4.423***	-4.457***	-4.652***	-0.374	-0.376	-0.363	-0.388
	(0.892)	(0.892)	(0.882)	(0.884)	(0.525)	(0.522)	(0.524)	(0.542)
South	-4.575***	-4.473***	-4.714***	-4.754***	-0.422	-0.478	-0.416	-0.419
	(1.001)	(1.006)	(0.996)	(0.993)	(0.656)	(0.663)	(0.660)	(0.665)
West	-5.555***	-5.563***	-5.565***	-5.703***	-1.065*	-1.062*	-1.060*	-1.087*
	(0.980)	(0.979)	(0.977)	(0.981)	(0.523)	(0.521)	(0.521)	(0.530)
Vending	-1.054	-1.029	-1.076*	-1.088*	-0.191	-0.202	-0.190	-0.193
	(0.539)	(0.542)	(0.539)	(0.540)	(0.300)	(0.300)	(0.301)	(0.301)
Coordinator	1.830*	1.854*	1.839*	1.822*	0.533	0.529	0.530	0.514
	(0.742)	(0.743)	(0.741)	(0.740)	(0.485)	(0.484)	(0.485)	(0.482)
Food Policy	0.390	0.415	0.371	0.364	0.371	0.354	0.373	0.367
	(0.536)	(0.539)	(0.534)	(0.538)	(0.276)	(0.274)	(0.276)	(0.276)

continued…

Table D.1 (continued). Additional Income Specifications, Total Entrees and Total Fruit

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total Entrees				Total Fruit			
Month (Month1 Omitted)								
Month2	1.179	1.186	1.168	1.178	-1.352*	-1.355*	-1.352*	-1.350*
	(0.861)	(0.859)	(0.860)	(0.856)	(0.615)	(0.616)	(0.615)	(0.616)
Month3	1.426	1.443	1.399	1.390	-1.039	-1.048	-1.039	-1.039
	(0.745)	(0.743)	(0.744)	(0.738)	(0.563)	(0.565)	(0.563)	(0.563)
Constant	562.098	-0.016	4.968	2.179	-22.363	2.140	1.044	5.811
	(360.977)	(2.332)	(3.525)	(16.665)	(199.856)	(1.344)	(2.065)	(10.326)
R^2	0.206	0.206	0.209	0.213	0.074	0.074	0.074	0.075

Number of observations for each regression is 816. Standard errors are in parentheses. *, **, *** indicate significance at α = 10%, 5% and 1%, respectively.

Table D.2. Additional Specifications, Total Vegetables and Green Vegetables

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	Total Vegetables				Green Vegetables			
LnIncome	-38.918	-	-	-	-11.752	-	-	-
	(44.006)				(11.942)			
$LnIncome^2$	1.849	-	-	-	0.570	-	-	-
	(2.028)				(0.551)			
Income	-	0.263	-0.464	5.918	-	0.126*	-0.071	1.678
		(0.216)	(0.838)	(8.396)		(0.051)	(0.202)	(2.273)
$Income^2$	-	-	0.060	-1.359	-	-	0.016	-0.356
			(0.066)	(2.060)			(0.017)	(0.554)
$Income^3$	-	-	-	0.130	-	-	-	0.032
				(0.212)				(0.057)
$Income^4$	-	-	-	-0.004	-	-	-	-0.001
				(0.008)				(0.002)
Attained BA	-0.512	-0.732	-0.455	-0.486	-0.737	-0.791	-0.716	-0.733
	(2.911)	(2.832)	(2.906)	(2.930)	(0.629)	(0.620)	(0.629)	(0.632)
Race (White Omitted)								
Black	-2.676**	-2.571**	-2.676***	-2.543**	0.634*	0.658*	0.629*	0.674*
	(0.811)	(0.784)	(0.802)	(0.810)	(0.266)	(0.260)	(0.264)	(0.268)
Hispanic	-1.407	-1.382	-1.406	-1.377	-0.132	-0.126	-0.133	-0.125
	(0.758)	(0.755)	(0.756)	(0.760)	(0.220)	(0.218)	(0.219)	(0.218)
Other	-4.344**	-4.157**	-4.405**	-4.211**	-0.758*	-0.720*	-0.787*	-0.719*
	(1.473)	(1.421)	(1.462)	(1.452)	(0.365)	(0.346)	(0.358)	(0.362)

continued…

Table D.2 (continued). Additional Specifications, Total Vegetables and Green Vegetables

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	Total Vegetables				Green Vegetables			
Urbanicity (Urban Omitted)								
Suburban	0.036	0.053	0.028	0.045	0.102	0.105	0.098	0.103
	(0.427)	(0.426)	(0.427)	(0.426)	(0.120)	(0.119)	(0.120)	(0.120)
Rural	0.826	0.846	0.826	0.866	-0.052	-0.048	-0.053	-0.041
	(0.601)	(0.590)	(0.596)	(0.598)	(0.147)	(0.145)	(0.146)	(0.146)
ln(Enrollment)	0.542***	0.528***	0.545***	0.530***	0.086*	0.083*	0.088*	0.083*
	(0.134)	(0.137)	(0.135)	(0.134)	(0.035)	(0.035)	(0.035)	(0.035)
Region (North Omitted)								
Midwest	0.781	0.775	0.753	0.684	0.301*	0.299*	0.293*	0.268
	(0.501)	(0.503)	(0.509)	(0.513)	(0.148)	(0.148)	(0.149)	(0.150)
South	2.259**	2.310***	2.202**	2.167**	0.226	0.236	0.207	0.195
	(0.687)	(0.687)	(0.695)	(0.703)	(0.168)	(0.168)	(0.170)	(0.171)
West	-0.568	-0.573	-0.577	-0.607	-0.173	-0.173	-0.175	-0.187
	(0.535)	(0.535)	(0.536)	(0.543)	(0.153)	(0.152)	(0.152)	(0.153)
Vending	-0.524	-0.512	-0.531	-0.529	-0.006	-0.004	-0.009	-0.008
	(0.355)	(0.354)	(0.355)	(0.354)	(0.093)	(0.092)	(0.092)	(0.092)
Coordinator	-0.276	-0.266	-0.268	-0.241	0.038	0.040	0.040	0.047
	(0.581)	(0.581)	(0.580)	(0.584)	(0.126)	(0.126)	(0.126)	(0.127)
Vegetable Policy	0.798*	0.808*	0.778*	0.755*	0.146	0.148	0.140	0.132
	(0.331)	(0.330)	(0.333)	(0.335)	(0.084)	(0.084)	(0.085)	(0.085)

continued…

Table D.2 (continued). Additional Specifications, Total Vegetables and Green Vegetables

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	Total Vegetables				Green Vegetables			
Month (Month1 Omitted)								
Month2	-0.529	-0.526	-0.531	-0.528	-0.116	-0.116	-0.117	-0.116
	(0.589)	(0.589)	(0.589)	(0.588)	(0.152)	(0.152)	(0.152)	(0.152)
Month3	-0.347	-0.340	-0.355	-0.357	-0.153	-0.152	-0.156	-0.157
	(0.531)	(0.530)	(0.531)	(0.532)	(0.142)	(0.142)	(0.142)	(0.142)
Constant	210.421	4.646**	6.600*	-3.325	60.767	-0.221	0.307	-2.493
	(238.995)	(1.471)	(2.788)	(12.219)	(64.691)	(0.402)	(0.697)	(3.303)
R^2	0.086	0.085	0.086	0.087	0.082	0.082	0.083	0.085

Number of observations for each regression is 816. Standard errors are in parentheses. *, **, *** indicate significance at α = 10%, 5% and 1%, respectively.

Table D.3. Additional Specifications, Red/Orange Vegetables and Legumes

	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
	Red/Orange Vegetables				Legumes			
LnIncome	-10.177	-	-	-	0.453	-	-	-
	(15.376)				(8.804)			
$LnIncome^2$	0.488	-	-	-	-0.006	-	-	-
	(0.712)				(0.404)			
Income	-	0.084	0.000	1.652	-	0.057	0.038	3.298*
		(0.069)	(0.266)	(3.093)		(0.049)	(0.192)	(1.660)
$Income^2$	-	-	0.007	-0.415	-	-	0.002	-0.764
			(0.023)	(0.756)			(0.015)	(0.414)
$Income^3$	-	-	-	0.045	-	-	-	0.075
				(0.077)				(0.043)
$Income^4$	-	-	-	-0.002	-	-	-	-0.003
				(0.003)				(0.002)
Attained BA	-0.795	-0.827	-0.795	-0.775	-1.249	-1.241	-1.233	-1.229
	(0.877)	(0.876)	(0.876)	(0.877)	(0.714)	(0.685)	(0.712)	(0.723)
Race (White Omitted)								
Black	-0.746**	-0.723**	-0.735**	-0.726**	-0.269	-0.280	-0.283	-0.234
	(0.273)	(0.268)	(0.271)	(0.274)	(0.160)	(0.155)	(0.159)	(0.159)
Hispanic	0.006	0.012	0.009	0.017	-0.144	-0.147	-0.147	-0.132
	(0.262)	(0.261)	(0.262)	(0.262)	(0.160)	(0.160)	(0.160)	(0.159)
Other	-0.206	-0.162	-0.190	-0.188	-0.261	-0.287	-0.293	-0.230
	(0.621)	(0.602)	(0.619)	(0.618)	(0.397)	(0.392)	(0.397)	(0.386)

continued…

Table D.3 (continued). Additional Specifications, Red/Orange Vegetables and Legumes

	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
	Red/Orange Vegetables				Legumes			
Urbanicity (Urban Omitted)								
Suburban	0.134	0.139	0.136	0.138	-0.060	-0.063	-0.064	-0.057
	(0.150)	(0.149)	(0.150)	(0.150)	(0.094)	(0.094)	(0.094)	(0.094)
Rural	-0.026	-0.020	-0.023	-0.018	-0.065	-0.069	-0.070	-0.053
	(0.181)	(0.179)	(0.180)	(0.181)	(0.141)	(0.138)	(0.140)	(0.139)
ln(Enrollment)	0.146***	0.143***	0.145***	0.145***	0.023	0.025	0.025	0.020
	(0.042)	(0.042)	(0.042)	(0.041)	(0.028)	(0.029)	(0.028)	(0.028)
Region (North Omitted)								
Midwest	0.101	0.098	0.096	0.098	0.055	0.057	0.056	0.035
	(0.173)	(0.172)	(0.174)	(0.176)	(0.110)	(0.110)	(0.112)	(0.113)
South	0.213	0.223	0.210	0.208	0.436**	0.429**	0.427**	0.413**
	(0.226)	(0.225)	(0.229)	(0.231)	(0.136)	(0.136)	(0.138)	(0.140)
West	-0.444*	-0.446*	-0.447*	-0.441*	-0.197*	-0.195*	-0.195*	-0.201*
	(0.191)	(0.191)	(0.191)	(0.192)	(0.099)	(0.099)	(0.099)	(0.101)
Vending	-0.153	-0.151	-0.153	-0.152	-0.123	-0.124	-0.125	-0.123
	(0.118)	(0.117)	(0.118)	(0.118)	(0.075)	(0.075)	(0.075)	(0.075)
Coordinator	-0.013	-0.011	-0.011	-0.003	0.025	0.025	0.025	0.039
	(0.172)	(0.173)	(0.173)	(0.173)	(0.122)	(0.122)	(0.122)	(0.124)
Vegetable Policy	0.094	0.096	0.092	0.091	0.097	0.095	0.094	0.086
	(0.106)	(0.105)	(0.107)	(0.107)	(0.072)	(0.072)	(0.072)	(0.073)

continued…

Table D.3 (continued). Additional Specifications, Red/Orange Vegetables and Legumes

	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
	Red/Orange Vegetables				Legumes			
Month (Month1 Omitted)								
Month2	-0.147	-0.146	-0.146	-0.147	-0.206	-0.207	-0.207	-0.207
	(0.208)	(0.208)	(0.208)	(0.208)	(0.130)	(0.130)	(0.130)	(0.130)
Month3	-0.208	-0.207	-0.208	-0.208	-0.118	-0.119	-0.119	-0.120
	(0.191)	(0.191)	(0.191)	(0.191)	(0.123)	(0.123)	(0.123)	(0.123)
Constant	53.827	0.450	0.674	-1.627	-2.845	1.026**	1.079	-3.795
	(83.085)	(0.507)	(0.893)	(4.522)	(47.970)	(0.324)	(0.631)	(2.339)
R^2	0.050	0.050	0.050	0.051	0.058	0.058	0.058	0.060

Number of observations for each regression is 816. Standard errors are in parentheses. *, **, *** indicate significance at α = 10%, 5% and 1%, respectively.

Table D.4. Additional Specifications, Starchy Vegetables and Other Vegetables

	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)
	Starchy Vegetables				Other Vegetables			
LnIncome	-15.805	-	-	-	-11.565	-	-	-
	(11.415)				(13.313)			
$LnIncome^2$	0.741	-	-	-	0.543	-	-	-
	(0.524)				(0.616)			
Income	-	0.066	-0.163	1.403	-	0.055	-0.167	4.481*
		(0.052)	(0.215)	(2.212)		(0.059)	(0.240)	(2.226)
$Income^2$	-	-	0.019	-0.394	-	-	0.018	-1.139*
			(0.017)	(0.527)			(0.020)	(0.545)
$Income^3$	-	-	-	0.046	-	-	-	0.121*
				(0.053)				(0.056)
$Income^4$	-	-	-	-0.002	-	-	-	-0.004*
				(0.002)				(0.002)
Attained BA	-1.343	-1.430*	-1.343	-1.318	0.468	0.393	0.477	0.518
	(0.740)	(0.725)	(0.739)	(0.743)	(0.729)	(0.738)	(0.730)	(0.728)
Race (White Omitted)								
Black	-0.391	-0.342	-0.376	-0.373	-0.222	-0.186	-0.218	-0.180
	(0.265)	(0.257)	(0.261)	(0.267)	(0.291)	(0.281)	(0.290)	(0.288)
Hispanic	-0.528*	-0.516*	-0.524*	-0.517*	0.029	0.038	0.030	0.051
	(0.215)	(0.212)	(0.213)	(0.216)	(0.258)	(0.255)	(0.256)	(0.256)
Other	-1.452**	-1.360**	-1.438**	-1.447**	-1.207**	-1.143**	-1.219**	-1.185**
	(0.446)	(0.437)	(0.441)	(0.447)	(0.413)	(0.397)	(0.405)	(0.413)

continued…

Table D.4 (continued). Additional Specifications, Starchy Vegetables and Other Vegetables

	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)
	Starchy Vegetables				Other Vegetables			
Urbanicity (Urban Omitted)								
Suburban	-0.094	-0.085	-0.093	-0.091	0.170	0.176	0.168	0.176
	(0.111)	(0.111)	(0.111)	(0.111)	(0.117)	(0.117)	(0.117)	(0.116)
Rural	0.210	0.221	0.215	0.218	0.302	0.308	0.302	0.319
	(0.158)	(0.158)	(0.158)	(0.158)	(0.166)	(0.164)	(0.165)	(0.166)
ln(Enrollment)	0.027	0.021	0.026	0.027	0.080	0.075	0.080	0.078
	(0.036)	(0.036)	(0.036)	(0.036)	(0.047)	(0.046)	(0.046)	(0.047)
Region (North Omitted)								
Midwest	0.411**	0.408**	0.401**	0.407**	0.371*	0.370*	0.363*	0.357*
	(0.145)	(0.145)	(0.146)	(0.147)	(0.151)	(0.150)	(0.152)	(0.156)
South	0.669***	0.693***	0.659***	0.658***	0.662**	0.681**	0.647**	0.636**
	(0.167)	(0.166)	(0.168)	(0.169)	(0.229)	(0.227)	(0.231)	(0.234)
West	-0.235	-0.238	-0.239	-0.230	-0.098	-0.099	-0.101	-0.091
	(0.144)	(0.144)	(0.144)	(0.145)	(0.173)	(0.172)	(0.173)	(0.175)
Vending	-0.116	-0.110	-0.116	-0.115	-0.210*	-0.205*	-0.211*	-0.208*
	(0.098)	(0.098)	(0.098)	(0.098)	(0.095)	(0.094)	(0.095)	(0.095)
Coordinator	0.011	0.015	0.014	0.021	-0.182	-0.179	-0.180	-0.158
	(0.129)	(0.129)	(0.129)	(0.129)	(0.159)	(0.158)	(0.158)	(0.159)
Vegetable Policy	0.177	0.182	0.172	0.172	0.071	0.075	0.065	0.058
	(0.098)	(0.097)	(0.098)	(0.098)	(0.090)	(0.089)	(0.090)	(0.090)

continued…

Table D.4 (continued). Additional Specifications, Starchy Vegetables and Other Vegetables

	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)
	Starchy Vegetables				Other Vegetables			
Month (Month1 Omitted)								
Month2	0.001	0.003	0.002	0.001	-0.083	-0.082	-0.083	-0.084
	(0.144)	(0.144)	(0.144)	(0.144)	(0.151)	(0.151)	(0.151)	(0.151)
Month3	0.099	0.102	0.098	0.098	0.033	0.035	0.031	0.030
	(0.128)	(0.128)	(0.128)	(0.128)	(0.132)	(0.132)	(0.132)	(0.132)
Constant	86.224	1.677***	2.294**	0.172	61.734	-0.012	0.585	-6.044
	(62.189)	(0.407)	(0.711)	(3.316)	(71.980)	(0.486)	(0.799)	(3.270)
R^2	0.151	0.150	0.151	0.152	0.059	0.058	0.060	0.063

Number of observations for each regression is 816. Standard errors are in parentheses. *, **, *** indicate significance at α = 10%, 5% and 1%, respectively.

Appendix E. Joint F Tests

Table E.1. Joint F Tests for Total Entrée, Total Fruit, and Total Vegetable

	Model						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Total Entree							
Income	15.741***	9.261***	2.091**	-	-	0.733	-
Eligible	-	-	-	12.238***	2.805**	-	2.120*
Race	1.178	1.146	1.220	0.543	0.551	1.225	0.246
Urbanicity	2.231*	2.411**	2.376**	1.712	1.686	0.516	0.552
Region	12.037***	11.764***	12.118***	12.876***	11.518***	6.309***	6.247***
Month	1.771	1.968	1.982	1.501	1.705	2.046	2.840*
Total Fruit							
Income	1.677	4.142**	1.295	-	-	0.423	-
Eligible	-	-	-	6.283***	1.194	-	0.277
Race	1.046	1.060	0.980	1.367	0.973	0.203	0.529
Urbanicity	2.266	2.243*	2.512*	1.961	2.005	0.864	0.614
Region	1.697	1.740	1.914	2.051*	1.939	0.940	0.699
Month	2.407*	2.404*	2.370*	2.642*	2.483*	2.894**	3.329**

continued…

Table E.1 (continued). Joint F Tests for Total Entrée, Total Fruit, and Total Vegetable

	Model						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Total Vegetable							
Income	0.956	1.019	0.504	-	-	0.032	-
Eligible	-	-	-	3.767	0.982	-	0.861
Race	5.175***	5.478***	5.230***	3.486***	3.522***	1.577	1.507
Urbanicity	1.357	1.422	1.439	1.437	1.281	1.265	0.478
Region	5.939	6.627***	6.843***	6.859***	6.923***	8.588***	7.399***
Month	0.402	0.381	0.364	0.466	0.382	1.808	1.655

Notes: F jointly tests the hypothesis that coefficients for each variable are different than zero. Results from Models 1-7 can be found in Tables 3.6 – 3.12. Number of observations for each regression is 816. *, **, *** indicate significance at α = 10%, 5% and 1%, respectively.

Appendix F. School Menu Example

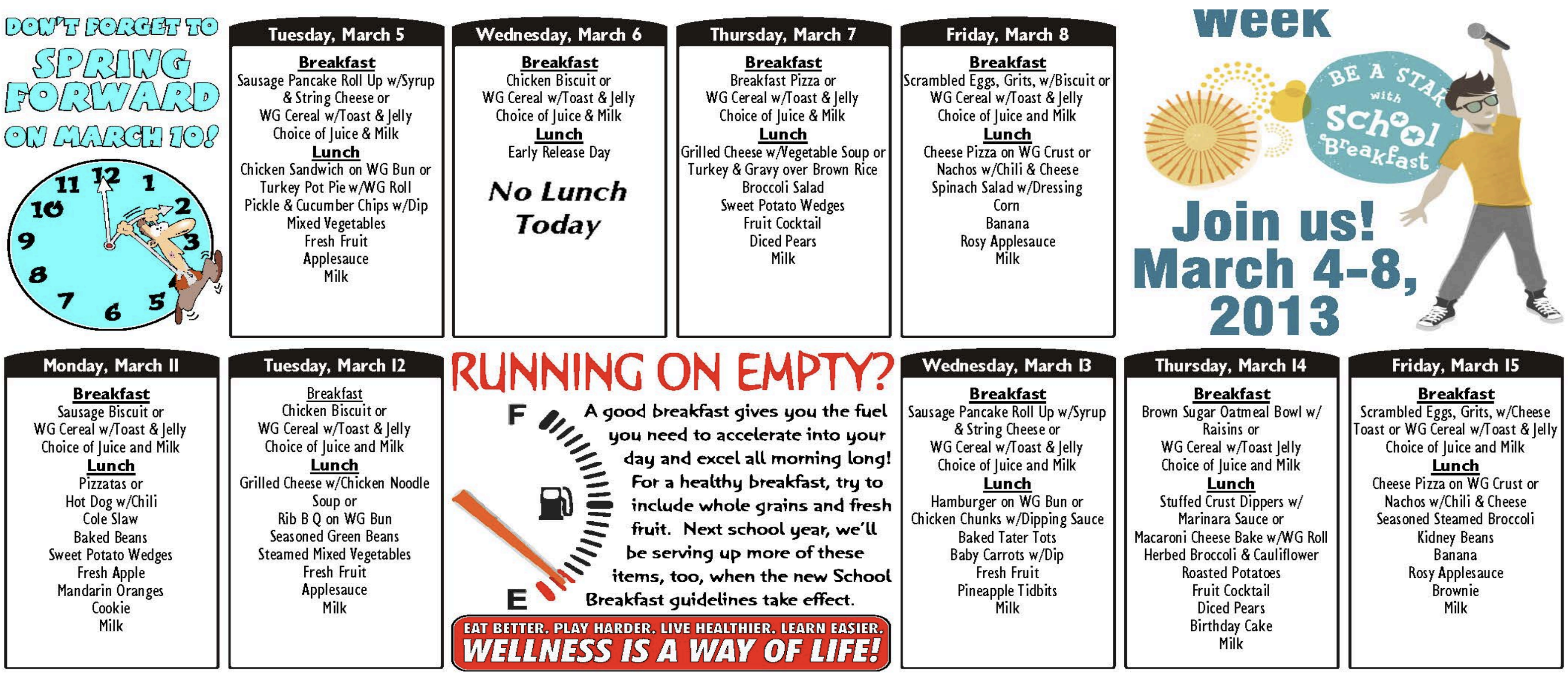

Figure F.1. School Lunch Menu, March 2013

Appendix G. Entrée Nutritionals

Table G.1. Food Energy and Nutrients for All Entrees

Entree	Calories (kCal)	Fat (g)	Sodium (mg)	Protein (g)	Carbs (g)	Percent of Total Sales	Number of Days Offered	Total Entrees Purchased Per Days Served
Barbeque on whole grain bun	357.0	14.5	901.0	22.0	34.0	2.63%	6	1,226.2
Cheese or pepperoni pizza on whole grain crust†	310.0	13.0	540.0	20.0	29.0	1.69%	2	2,365.5
Cheese pizza on whole grain crust	310.0	12.0	490.0	21.0	31.0	7.35%	10	2,056.2
Chicken alfredo with whole grain roll	579.0	25.3	730.0	34.5	51.5	0.36%	1	1,013.0
Chicken chunks with honey mustard sauce & whole grain roll†	438.5	22.8	917.5	21.5	38.0	0.74%	1	2,073.0
Chicken chunks with honey mustard sauce†	348.5	21.5	762.5	18.0	21.5	0.76%	1	2,138.0
Chicken nuggets with honey mustard sauce & whole grain roll†	416.0	23.3	811.0	18.5	35.5	2.81%	3	2,620.3
Chicken nuggets with honey mustard sauce†	326.0	22.0	656.0	15.0	19.0	8.99%	8	3,144.3
Chicken sandwich on whole grain bun†	316.5	11.5	727.5	19.5	36.0	10.58%	10	2,960.3
Deli sliced turkey on whole grain bun†	146.5	2.2	494.0	13.0	18.1	0.62%	4	430.3
Enchilada pie with whole grain roll	445.0	15.5	1087.0	16.5	59.0	0.12%	2	169.0
Fish nuggets with tarter sauce†	225.0	11.5	505.0	13.0	18.5	0.24%	2	337.5
Grilled cheese with chicken noodle soup†	360.0	14.0	1301.0	21.0	37.0	2.44%	3	2,277.3
Grilled cheese with vegetable soup†	308.0	12.0	1069.0	14.0	33.0	1.40%	2	1,960.5
Grilled cheese†	250.0	11.0	700.0	11.0	27.0	1.87%	3	1,747.0
Hamburger on whole grain bun†	291.5	12.0	509.5	22.5	23.0	6.57%	7	2,627.0
Hot dog with chili	344.0	19.0	847.0	12.5	30.0	1.56%	3	1,456.7

continued…

Table G.1 (continued). Food Energy and Nutrients for All Entrees

Entree	Calories (kCal)	Fat (g)	Sodium (mg)	Protein (g)	Carbs (g)	Percent of Total Sales	Number of Days Offered	Total Entrees Purchased Per Days Served
Hot ham & cheese on whole grain bun†	290.0	13.5	1000.0	18.0	23.0	0.31%	1	880.0
Italian spaghetti†	306.0	6.3	345.0	21.3	39.5	1.30%	3	1,211.3
Italian spaghetti with garlic toast†	386.0	7.3	450.0	24.3	55.5	0.52%	1	1,467.0
Macaroni and cheese bake with whole grain roll	463.0	19.3	1283.0	27.5	43.5	0.81%	4	568.8
Mandarin orange chicken rice bowl†	284.0	5.5	422.5	14.0	41.5	0.40%	1	1,108.0
Mexican beef soft tacos with trimmings	453.0	17.3	616.0	22.5	22.0	4.24%	5	2,370.4
Mozzarella cheese sticks with marinara sauce†	287.0	10.3	800.0	17.7	34.5	0.39%	1	1,102.0
Nachos with chili and cheese	304.0	17.0	942.0	23.5	23.0	5.88%	8	2,056.9
Pizzatas	360.0	21.0	930.0	18.0	26.0	3.43%	4	2,396.5
Popcorn chicken with honey mustard sauce and whole grain roll†	413.0	23.3	1114.0	15.5	36.5	3.71%	4	2,593.3
Popcorn chicken with honey mustard sauce†	323.0	22.0	959.0	12.0	20.0	2.40%	3	2,238.3
“Rib-b-q” on whole grain bun	420.0	25.5	790.0	18.0	27.0	1.18%	3	1,097.3
Scrambled eggs, grits, sausage patty†	351.0	20.1	527.0	25.0	17.5	1.76%	2	2,457.0
Stuffed baked potato with ham and cheese and crackers†	335.0	12.0	1220.0	21.0	36.0	1.07%	3	999.7
Stuffed baked potato with chili and cheese	264.0	10.0	837.0	12.5	32.0	0.34%	1	960.0
Stuffed crust dippers with marinara sauce	340.0	14.3	1005.0	19.0	29.5	5.36%	5	2,997.2
Teriyaki dippers over brown rice†	286.5	10.0	623.0	17.0	29.5	1.73%	5	970.0
Turkey and gravy over brown rice	220.0	10.0	770.0	17.0	26.0	1.17%	5	654.6
Turkey pot pie with whole grain roll	380.0	12.3	887.0	23.5	39.5	0.77%	5	432.0
Vegetarian Tray†	325.0	12.5	395.0	14.0	37.5	12.46%	66	527.8

continued…

Table G.1 (continued). Food Energy and Nutrients for All Entrees

Entree	Calories (kCal)	Fat (g)	Sodium (mg)	Protein (g)	Carbs (g)	Percent of Total Sales	Number of Days Offered	Total Entrees Purchased Per Days Served
Mean	339.5	14.9	782.8	18.8	31.9	-	3	1,613.2
Standard Deviation	79.5	5.9	254.4	4.9	10.1	-	10.5	855.4
Minimum	146.5	2.2	345.0	11.0	17.5	0.12%	1	169.0
Maximum	579.0	25.5	1301.0	34.5	59.0	12.46%	66	3,144.3
Weighted Average	334.5	15.4	722.3	18.5	29.9	-	-	-

Notes: There are 279,698 total transactions. Weighted average is weighted by the percent of total sales. Pizzatas are mozzarella cheese, pepperoni, and marinara sauce wrapped in pizza crust (Rich's Food Service 2011b). Rib-b-q is a boneless, chopped pork rib patty (AdvancePierre Foods 2013). Stuffed crust dippers are mozzarella cheese wrapped in pizza crust (Rich's Food Service 2011a) and served with marinara sauce. Monthly menus did not consistently list which dipping sauce was offered with each entrée. After consultation with the district Food Services, the authors assumed bite-sized chicken entrees were served with honey mustard sauce, fish nuggets served with tartar sauce, and stuffed crust dippers and mozzarella sticks served with marinara sauce. For food items supplied by multiple vendors, macronutrients are calculated by the median value of all possible options. These entrées are denoted with †.

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